HAM TIPS

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A Panoramic Adaptor with a Circular Base Line

By W. E. Babcock*

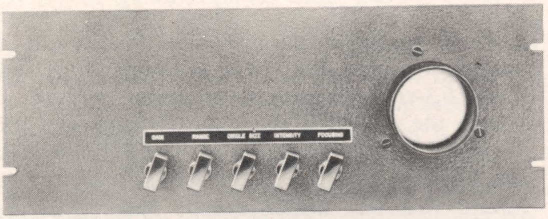

Figure 1. Panel view of the circular base line panadaptor showing position of the front controls and C R tube face.

SIMULTANEOUS visual reception of a large number of radio signals over a broad band of frequencies is provided by the panoramic adaptor. It may be used with almost any type of receiver and provides an indication of the frequency, type, and strength of all signals within a given bandwidth (centered at the frequency to which the receiver is tuned). When used to spot unoccupied channels in the band it can be an invaluable aid in avoiding interference problems. When used with a calibrated scale it becomes an accurate frequency meter. The amateur who owns a panoramic adaptor will no doubt find many additional uses for it.

Basically, a panoramic adaptor is a superheterodyne receiver with a broadly tuned r f stage and a narrow-band i f stage. However, in the conventional superheterodyne receiver, the local oscillator is fixed in frequency at any one time, while in the panoramic adaptor, the local-oscillator is frequency modulated over a given band. In commercial panoramic adaptors, all signals within the bandwidth covered by the r f stage are shown on a cathode-ray tube as vertical "pips" on a horizontal base line. In the panoramic adaptor described here (and shown in Figure 1), a circular base line is used on which signals appear as radial pips extending toward the center of the screen. The frequency of any signal appearing as a pip on the screen is determined by the position of the pip on the circumference of the circle as shown in Figure 2. The center frequency (to which the companion receiver is tuned) is shown at zero, while other signals are shown in proper frequency relationship to this zero.

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General Circuit Description

A circuit diagram of the panoramic adaptor is given in Figure 5. The signal input to the adaptor is taken from the plate of the converter tube in the receiver. The 6AU6 r f stage is tuned to the intermediate frequency of the receiver and has a rising frequency characteristic either side of the center frequency to compensate for the drooping frequency characteristic resulting from the selectivity of the r f stage in the receiver. The plate circuit of the 6BE6 mixer stage is tuned to 160 kc, while the oscillator section is varied over a range of 50 kc above and below 616 kc (456 kc, the usual receiver i f, + 160 kc) at a rate of 60 times per second. The sawtooth voltage driving the reactance modulator tube, and the circular sweep voltage for the cathode-ray tube are both derived from the 60-cycle line voltage.

Plate and screen voltages for all tubes except the cathode-ray tube are obtained from a conventional full-wave rectifier. The screen voltage for the reactance modulator tube is held constant at 150 volts by the OA2 voltage regulator tube. The anode voltage for the cathode-ray tube is obtained from a voltage-doubler circuit in which the output voltage is added to that from the full-wave rectifier to give a total second-anode voltage of approximately 1100 volts. **This high voltage is dangerous.** Extreme care must be exercised if it is necessary to work on the adaptor with the power on. Be sure the high voltage filter capacitors are discharged when making tests with the power off.

Use of Standard Components

All components used in the construction of the panoramic adaptor are standard receiver replacement components. Many hams will no doubt have many of the parts on hand. The transformers used in the i f stages are designed to tune to 175 kc. However, their tuning range is such that they may easily be tuned to 160 kc. Maximum width of the pips obtained when these transformers are used is approximately 5 kc at the base line. This bandwidth is sharp enough for observing signals differing by less than 5 kc.

Construction and Layout Details

The adaptor is constructed on a 10"x14"x3" chassis with a standard 7"x19"x1/8" rack mounting panel. Figures 3 and 4 illustrate the chassis layout. No special precautions are required in constructing the adaptor other than those normally practiced in constructing receiver i f stages. The cathode-ray tube, of course, should be mounted as far from the power transformer as possible to minimize hum pickup on the deflection plates. If difficulty is experienced with hum pickup on the grid of the cathode-ray tube, it may be necessary to add a 4-μf capacitor (C_{32}) from the cathode of the 3KP1 to the arm of the intensity control.

Auxiliary Use

For the station that does not have a modulation monitor, the cathode-ray tube in the panoramic adaptor can be used for this purpose. For this use, capacitors C_{28}, C_{29}, C_{30}, and C_{31} should be connected by means of a 4-pole double-throw relay so they will connect the deflection plates of the cathode-ray tube to the plates of the deflection amplifier tubes in the adaptor on "receive" and to the r f and modulating voltages of the transmitter on "transmit." The coupling to the transmitter should be such that the voltage ratings of C_{28}, C_{29}, C_{30}, and C_{31} are not exceeded. For more detailed information on the use of a cathode-ray tube as a modulation indicator, see Ham Tips of January-April, 1948.

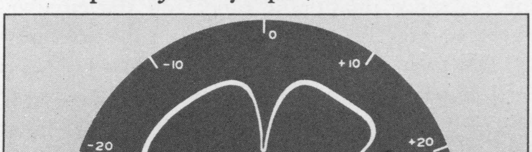

Figure 2. The position of the pips on the circumference of the circle indicates the frequency of the received signals.

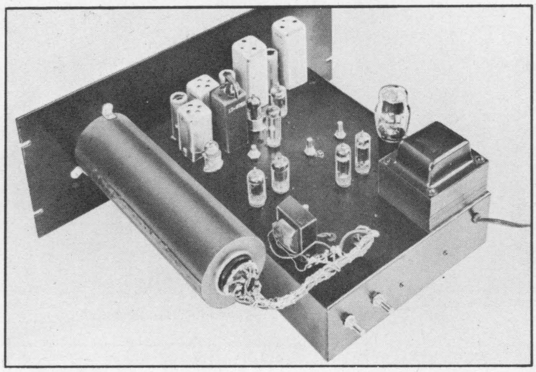

Figure 3. A bird's eye view of the panadaptor illustrates the chassis layout. The cylindrical sleeve supports the c-r tube.

Alignment Procedure

Variable resistor R_{35} and capacitor C_{26} form a phase-shifting network which applies two sinusoidal voltages 90° out of phase to the push-pull grids of the deflection amplifiers. R_{35} should be varied until the best circle is obtained. A separate 6.3-volt filament transformer is used to supply the voltage to the phase-shifting network. It would be possible to supply this voltage from the filament winding of the power transformer, except that any heater-cathode leakage in the tubes would result in spikes being superimposed on the heater voltage and consequent distortion of the circle. If the line voltage has a perfect sinusoidal wave form, the circle on the screen of the cathode-ray tube will be very nearly perfect. Although in most cases, the line voltage will vary slightly from a perfect sine wave, the resulting pattern will still be very nearly a circle.

During alignment of the i f stage, a high-impedance dc voltmeter, such as an RCA Voltohmyst*, is connected across the detector load resistance (R_{14}). With R_{22} set at zero, a 160-kc signal from a signal generator is applied to the signal grid (grid No. 3) of the 6BE6 and the i f transformers are peaked for maximum dc voltage across the detector load resistance.

Variable capacitor C_{14} controls both the magnitude and phase of the r f voltage appearing at the control grid of the reactance tube. Its setting is not critical, but during the adjustments described in the following paragraph, it should be set near maximum capacitance. If it is desired to increase the frequency range of the adaptor, at a sacrifice of linearity, approximately 50 kc more deviation may be obtained by setting C_{14} to maximum capacitance.

Sweep padder, R_{21} is used to set the amplitude of the sawtooth voltage obtained from the plate of the sawtooth generator so that the total frequency deviation of the local oscillator is exactly 100 kc when R_{22} is at maximum. It should initially be set at about half scale. The center fre-

*Reg. Trade Mark, U. S. Pat. Off.

quency f_0 should be set to the proper value (616 kc if the companion receiver has an i f of 456 kc). Capacitors C_A and C_B which are contained in oscillator transformer T_3 are used to set f_0. C_A is a coarse tuning adjustment which may be turned with a screw driver; C_B is a fine tuning adjustment controlled by a knob at the top of T_3. However, R_{20} in the cathode circuit of the reactance tube will also have a slight effect on f_0. R_{20} is used to set the cathode bias of the reactance tube so that the frequency deviation of the oscillator is linear. It should be set initially to give a cathode-to-ground voltage of approximately 2 volts. With control R_{22} set at minimum and with a 456-kc signal applied to the signal grid of the mixer stage, C_B is then adjusted to give maximum dc voltage across R_{14}. Control R_{22} is then set at maximum. A pip, corresponding to the 456-kc input signal, will now appear on the screen of the cathode-ray tube. The tube may be rotated so that this pip appears at the top of the screen. The signal generator frequency should now be shifted 50 kc above and below the center frequency of 456 kc. The pip will be seen to rotate around the circle as the frequency is shifted. When the deviation of the local oscillator is set to exactly $\pm$ 50 kc, the pip will travel almost the full 360° of the circle as the signal-generator frequency is shifted from 406 to 506 kc. If the pip moves around the circle before the range is covered, the sawtooth voltage applied to the grid of the reactance tube is not great enough and the resistance of sweep padder R_{21} should be decreased until the proper frequency range is covered. If too great a range is covered, the resistance of R_{21} should be increased.

Linearity and Bandwidth

Approximately 10° at the bottom of the circle is taken up by the retrace of the sawtooth voltage driving the reactance tube. During this interval, the local oscillator is being frequency-modulated 50 kc each side of f_0 in the same manner as during the rising portion of the sawtooth, except that the deviation is in the opposite direction and occurs in a much shorter time. This deviation causes a small pip to appear at the bottom of the circle whenever a signal is applied to the adaptor. Since this pip occupies such a small portion of the circle (approximately 10°), it will appear to remain stationary as the input signal frequency is varied. It may be used as a dividing marker between 406 and 506 kc.

After the frequency deviation of the local oscillator is set to the proper value, the linearity of the deviation should be checked. If the deviation is linear, half the circle will be traced for a 50-kc frequency change of the signal generator. If either more or less than half the circle is traced, R_{20} should be adjusted slightly. Since any adjustment of R_{20} causes a slight shift in f_0, the setting of C_B must be changed to correct it. If the linearity is poorer, the adjustment of R_{20} has been in the wrong direction. After R_{20} is set for best linearity, it may be found that the frequency range covered has changed and R_{21} will have to be adjusted also.

Capacitors C_1 and C_5 are used to overcouple the r f transformers and thus give a rising frequency characteristic each side of the center frequency (456 kc for most receivers). The primaries of T_1 and T_2 are tuned approximately 10 kc below the maximum frequency to be received (496 kc). The secondaries of T_1 and T_2 are tuned approximately 10 kc above the lowest frequency to be received (416 kc). Approximate alignment is obtained by applying a 496-kc signal from a signal generator to the input of the adaptor and adjusting the primaries of T_1 and T_2 for maximum deflection on the screen of the cathode-ray tube. The signal-generator frequency is then changed to 416 kc and the secondaries of T_1 and T_2 adjusted for maximum deflection.

Final Alignment

The final alignment should be done with the adaptor connected to the plate of the converter tube in the receiver with which it will be used by means of a 47,000-ohm isolating resistor (R_A). This resistor should be connected as close to the converter plate as possible and a shielded lead used between the resistor and the adaptor input. With the receiver tuned to approximately 3 Mc, set the signal generator to the same frequency and tune the receiver until the signal appears as a deflection at the top of the screen. Then change the signal generator frequency 50 kc higher, moving the deflection clock-wise to the bottom of the screen. Adjust the trimmers on T_1 and T_2 until

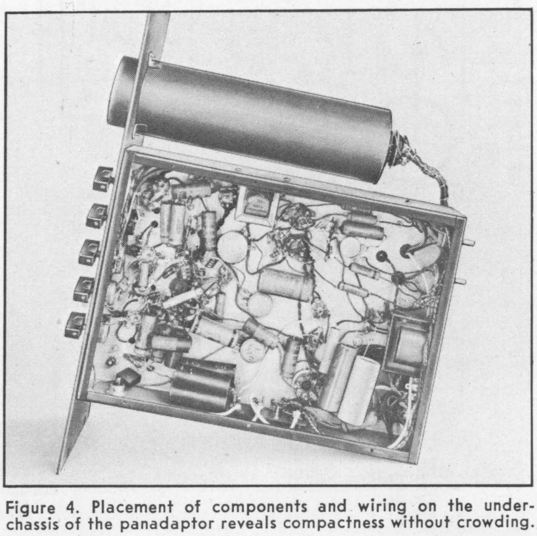

Figure 4. Placement of components and wiring on the under-chassis of the panadaptor reveals compactness without crowding.

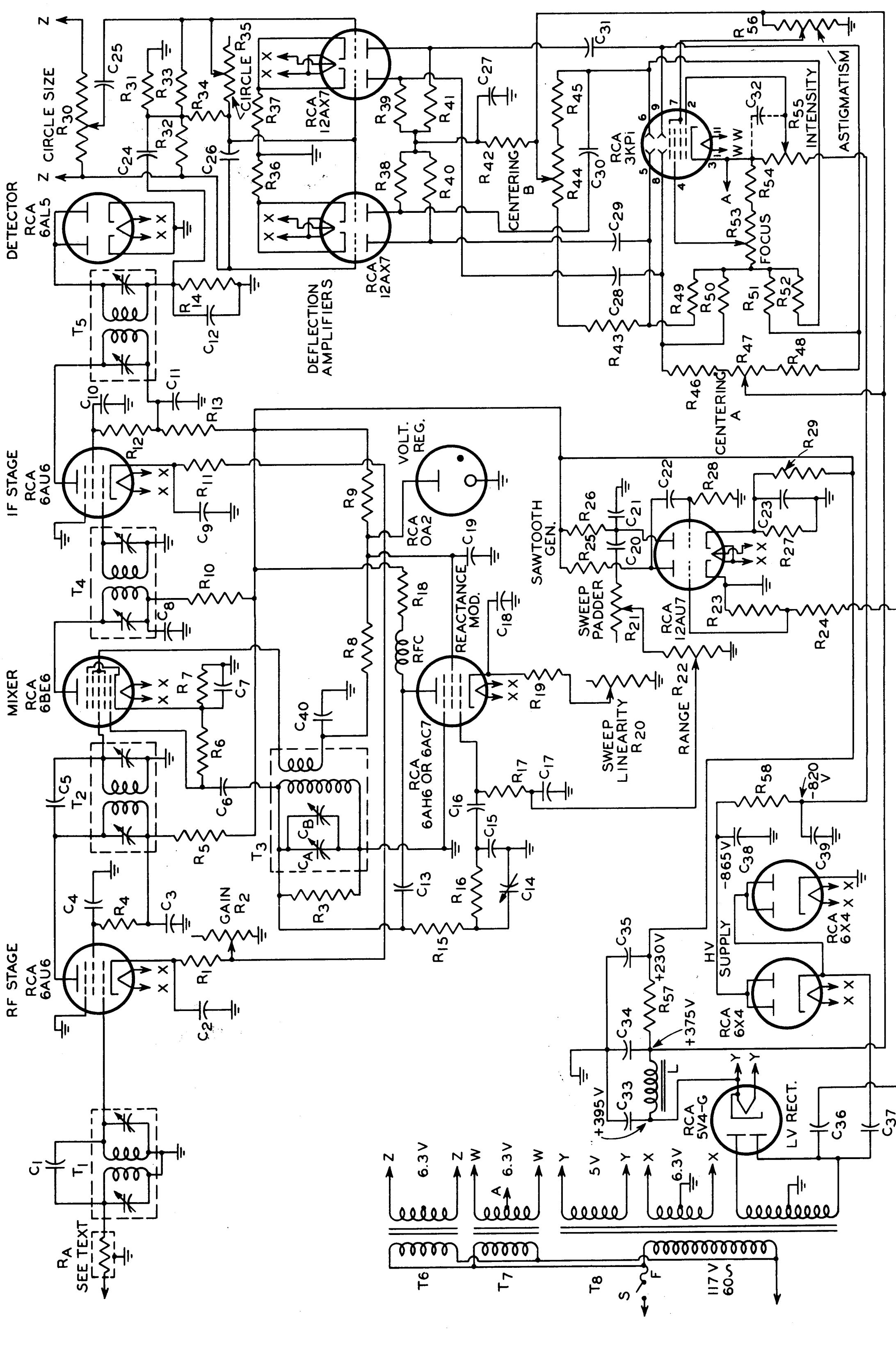

Figure 5. Schematic of the panadaptor.

the amplitude of the deflection is approximately the same as it was at the center. Then change the signal generator frequency 50 kc lower, moving the deflection counterclockwise to the bottom of the screen. Again adjust the trimmers to make the amplitude of the deflection approximately what it was at the center. This second adjustment will upset the first adjustment, and it will be necessary to go back and forth and to compromise on adjustments in order to make the gain as nearly uniform as possible over the entire 100-kc range.

Alignment for Other Frequencies

The r f stage of the adaptor may be aligned for center frequencies from about 420-500 kc. If the companion receiver has an intermediate frequency different from 456 kc, but falling within the 420-500 kc range, the alignment procedure is exactly as given above, except that it is necessary to correct the alignment frequencies of the r f stage and the local oscillator.

Calibration of Scale

If accurate frequency readings are desired a calibrated scale may be made up on lucite or other transparent material and placed in front of the cathode-ray tube screen. The scale may be calibrated using a signal generator to determine the desired calibration points. When the signals are obtained directly from a signal generator, it should be remembered that signals from 456 kc to 506 kc will appear on the left half of the circle, while signals from 456 kc to 406 kc will appear on the right half. When the signals are obtained from the output of the converter tube in the receiver, signals up to 50 kc above the receiver frequency will appear on the right half of the circle and signals up to 50 kc below the receiver frequency will appear on the left half.

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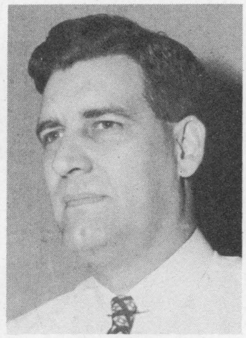
MEET THE GANG

GEORGE E. JONES, JR.



W2CBL since 1930
ex-W9BDJ since 1922
Age: 41
Employed in: Equipment Section, RCA Tube Department, Harrison, N. J.
Home QTH: 71 Lincoln Drive, Rochelle Park, N. J.
Graduate of: Kansas University '30.
Active on: 20 and 80 phone & cw.
Rig: 350 watts to pair RCA 812-A's.
XYL: Jean.
Harmonics: George—age 10, Phyllis—age 6.
Articles: DeLux 812-A Bandswitching Transmitter—Ham Tips.
Other Hobbies: Model railroads and table tennis.

PARTS LIST

C1, C5	47-uuf ceramic
C2, C3, C7, C8, C10, C11, C28, C29, C30, C31, C40	0.01-uf 400 V paper
C4, C9, C18, C25	0.1-uf 400 V paper
C6	68-uuf ceramic
C12, C13	470-uuf mica
C14	1—10-uuf ceramic trimmer
C15	15-uuf mica
C16	100-uuf 600 V paper
C17	270-uuf mica
C19	0.006-uf 400 V paper
C20	0.25-uf 400 V paper
C21, C22, C27, C36, C37	0.1-uf 600 V paper
C23	25-uf 25 WV electrolytic
C24	0.03-uf 400 V paper
C26	1-uf 600 V paper
C32	4-uf 150 WV electrolytic
C33, C34	16-uf 450 WV electrolytic
C35	40-uf 450 WV electrolytic
C38, C39	0.1-uf 2000 V paper
RA	47,000 ohms, in receiver connected to plate of converter tube
R1	100 ohms
R2	10,000 ohm potentiometer—linear taper
R3	51,000 ohms
R4, R12	22,000 ohms
R5, R10	4700 ohms 1 watt
R6	24,000 ohms
R7	150 ohms
R8	6800 ohms
R9	2200 ohms 5 watt
R11, R19	100 ohms
R13	3300 ohms 1 watt
R14	680,000 ohms
R15	20,000 ohms
R16	100,000 ohms
R17, R31, R32, R33, R34, R58	220,000 ohms
R18	3000 ohms 1 watt
R20	500,000 ohm potentiometer—linear taper
R21, R44, R47, R56	1 megohm potentiometer—linear taper
R22	100,000 ohm potentiometer—linear taper
R23, R24, R25, R26, R28, R54	1 megohm
R27	4700 ohms
R29	51,000 ohms 2 watt
R30	20 ohm potentiometer, 5 watt
R35	5000 ohm potentiometer—linear
R36	270 ohms
R37	390 ohms
R38, R39, R40, R41	27,000 ohms
R42	3300 ohms
R43, R45, R46, R48	3.9 megohms
R49, R50, R51, R52	20 megohms
R53	2 megohm potentiometer—linear taper
R55	0.5 megohm potentiometer—logarithmic taper
R57	2500 ohms, 10-watt
T1	456-kc i f transformer; Meissner 16-5740 or equiv.
T2	456-kc i f transformer; Meissner 16-5742 or equiv.
T3	Oscillator transformer; Meissner 17-6753 or equiv.
T4	175-kc i f transformer; Meissner 16-6649 or equiv.
T5	175-kc i f transformer; Meissner 16-6651 or equiv.
T6, T7	Filament transformer 6.3 volts, 1 amp; Thordarson T21F08 or equivalent
T8	Power transformer 350-0-350 volts 120 ma;—6.3 volts, 4.7 amp; 5 volts, 3 amp; Thordarson TS-24R05 or equivalent
S	SPST switch (mounted on R55)
F	Fuse
RFC	RF choke 30 mh
L	Filter choke—8 henrys—150 ma Thordarson T-20C54 or equivalent

All resistors 0.5 watt unless otherwise specified.

HAM TIPS

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Design and Application of High-Pass Filters

By
Mack Seybold, W2RYI*

Although filter theory is apt to be appreciated by the advanced amateur, the average ham prefers to avoid the subject because of the mathematics involved. If you would like to build a high-pass filter for your TV set to preserve peace in the family or to assist a neighbor in obtaining adequate low-frequency rejection in his receiver, this is the dope you have been waiting for. Easy-to-build filters are fully described.

THE causes of interference to television reception encountered when an amateur station is transmitting can be divided into three classifications: harmonic radiation from the transmitter, generation and radiation of harmonics by external non-linear devices** excited by the amateur signal, and incomplete rejection of the amateur fundamental signal by the television receiver. If an amateur transmitter has been TVI-proofed, and if the external producers of detrimental harmonic radiation have been eliminated, then most of the remaining interference difficulties can be attributed to inadequate receiver rejection.

Television receivers vary in ability to reject low-frequency signals. Some have a tuned rf stage and a built-in, high-pass filter. In many installations, in the vicinity of amateurs, these require no additional filtering. Some receivers have only a choke input to the rf tube, and no provision for the rejection of strong signals.

If a television receiver does not reject amateur signals from the 80- and 160-meter amateur bands, interference may be produced

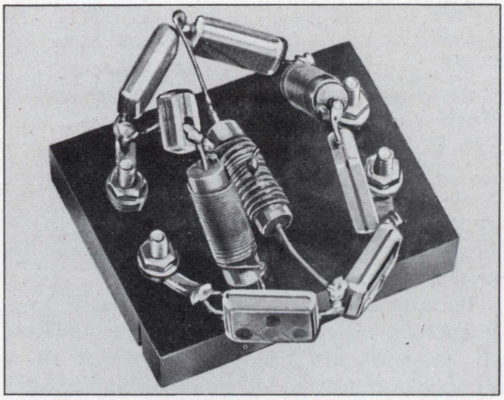


Fig. 1. A two-section, series-derived filter which can be connected to the antenna terminals on the TV receiver.

in the video amplifier. Signals from the 10- and 11-meter bands can produce interference in the if amplifier, and strong signals from practically all amateur bands can produce interference in the "front end" of the television receiver. Most of the difficulties arise in the front end, and the major phenomena involved are blocking, rectification, and heterodyning.

Blocking occurs when a strong extraneous signal reduces the gain of the receiver by taking over the avc action or by driving the control grid of an amplifier tube to a positive potential, thereby producing grid current which biases the stage to a potential at which no amplification can take place.

Rectification occurs in the grid-cathode circuit of an rf amplifier when an extraneous signal swings the grid beyond the linear portion of the tube's characteristic curve. Harmonics are then produced by this action, and they are exact multiples of the frequency of

*RCA Tube Dept., Harrison, N. J.

**Rectifiers, either oxide or thermionic, connected to electrical conductors. Also pipe junctions, air-duct and drain-pipe joints, telephone buttons, corroded ground clamps, radio receivers, etc.

the extraneous signal. When one of these harmonics falls in a television channel, a cross-hatched picture may be produced

Heterodyning occurs when an amateur signal and a second extraneous signal enter the receiver. For instance, a 14-Mc amateur signal can heterodyne the channel-2 picture carrier at 55.25 Mc into the middle of channel 4 at 69.25 Mc so that a "lacy" mixture of the two pictures is in evidence on channel 4.

The effects of heterodyning, rectification, if interference, etc., may be encountered individually or in combinations, but all are evidence that the TV receiver has inadequate low-frequency rejection. Devices to improve rejection may be installed at the antenna terminals of the television receiver, and one of the simplest of these devices is a pair of tuned traps.

Traps are effective only if the amateur transmitter is operated in a relatively narrow range of frequencies within one amateur band. When the amateur transmitter is operated over a considerable range of frequencies, several pairs of traps can be installed, but problems of matching the television antenna to the receiver are encountered. It is sometimes difficult to get multiple traps to work without causing signal attenuation in several television channels.

Because very few amateurs operate by preference on only one frequency, and because all amateurs are licensed to operate in a number of bands, six of which occur between the frequencies 1.75 and 30 Mc, tuned traps are usually inadequate, and a more efficient device, the high-pass filter, is required for the protection of a receiver located in the vicinity of an amateur transmitter.

Filter Requirements

A high-pass filter for a television receiver has two primary requirements. First, it should reject all signals below the lowest local television frequency. Second, it should function, at television frequencies, as a transmission line having a characteristic resistance equal to that of the television antenna feeder. A theoretically perfect high-pass filter would be capable of fulfilling these requirements; however, in actual practice, compromises must be made in "rejectability" to permit reasonable performance in the TV pass-bands.

For instance, if an attempt were made to design a high-pass filter that would reject all signals below 54 Mc and pass all signals above 55 Mc, the Q of the circuits required would be so high that it would be impossible to construct the device from available components. Even with the best coils and capacitors, the nearest peak-attenuation frequency can be set no nearer than five per cent of the cutoff frequency. Spurious responses that occur in the vicinity of the cutoff frequency of such a filter would also cause difficulties between 50 and 60 Mc. Therefore, rejection of signals from the 6-meter amateur band, especially in a location where channel 2 is assigned, is impractical with a high-pass filter. If a 6-meter signal is to be rejected, the installation of a separate set of tuned traps is the easiest solution to the problem.

For rejecting signals from all of the amateur bands below 30 Mc, however, a high-pass filter is the most practical device that can be installed. With a 25-Mc separation between the television portions of the spectrum and the 10-meter amateur band, there is plenty of room to juggle cutoff frequencies and peak-attenuation frequencies so that optimum conditions can be met for rejecting unwanted signals and accepting all television signals from channel 2 through channel 13.

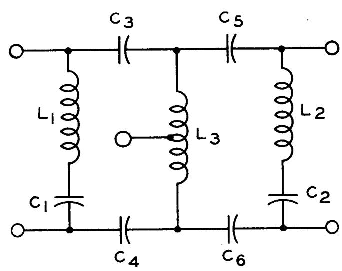


Fig 2. Two-section, series-derived, high-pass filter for a 300-ohm line (Cutoff: approx. 36 Mc).

C_1, C_2 15$\mu\mu$f, mica capacitor, $\pm$ 10% tolerance.

C_3, C_4, C_5, C_6 20$\mu\mu$f, mica capacitor $\pm$ 10% tolerance.

L_1, L_2 2.0μh, 24 turns of #28 DCC wire, coil length 5/8" on 1/4" diam. form. Correct inductance* can be obtained by adjusting the turns to resonate with the associated 15-$\mu\mu$f capacitor at 29 Mc, before setting turns with wax or coil dope.

L_3 0.66 μh, 13 turns of #28 DCC wire, coil length 5/8" on a 1/4" diam. form, center tapped. Correct inductance* can be obtained by adjusting turns to resonate at 19.8 Mc with an auxiliary 100-$\mu\mu$f capacitor.

**Note:* If measuring equipment or a grid-dip meter is available, inductances and resonant sections can be adjusted close to specified values. If measuring equipment is not available, however, the coil specifications should be followed closely and a reasonably good filter can be built.*

Constructional Details

The circuit and constructional data are given in *Fig.* 2 for a simple two section, high-pass filter that will work well on most television receivers that are 150 feet or more from an amateur transmitter. For receivers that are closer than 150 feet, or that require more than average filtering, a more elaborate filter may be required. A four-section, high-pass filter that has worked successfully in a number of difficult situations is shown in

C_1, C_2, C_7, C_8 50$\mu\mu$f, Cornell-Dubilier Type 5W capacitors, $\pm$ 5% tolerance.

C_3, C_4 20$\mu\mu$f, Cornell-Dubilier Type 5W capacitors, $\pm$ 10% tolerance.

C_5, C_6, C_9, C_{10} 15$\mu\mu$f, Cornell-Dubilier Type 5W capacitors, $\pm$ 10% tolerance.

L_1, L_2, L_7, L_8 0.62 μh, 10 turns, close spaced, of #28 DCC wire, wound on the associated 50-$\mu\mu$f capacitor. (Type 5W cases are approx. 3/16″x7/16″x11/16″.) The resonant frequency of each of these four LC units should be 29 Mc.

L_3, L_4 1.6 μh, 19 turns of #28 DCC wire on the associated 20-$\mu\mu$f capacitor. Adjust resonant frequency* to 27 Mc.

L_5, L_6 8.0 μh, 23 turns of #28 DCC wire on a ¾″ diam. form. Adjust the resonant frequency of each coil with its associated 15-$\mu\mu$f shunt capacitor to 14.2 Mc*.

L_A 1.05 μh, 16 turns #28 DCC wire, coil length ½″ on a ¼″ diam. form. Correct inductance* may be obtained by adjusting turns to resonate at 15.6 Mc with an auxiliary 100-$\mu\mu$f capacitor.

*For resonance specification requirements, see note under Fig. 2.

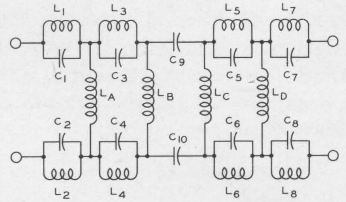


Fig. 3. Four-section, shunt-derived, high-pass filter for a 300-ohm line (Cutoff: 36.25 Mc).

L_B 0.79 μh, 13 turns of #28 DCC wire, coil length ⅝″ on a ¼″ diam. form. Adjust resonant frequency, using an auxiliary 100-$\mu\mu$f capacitor, to 18.3 Mc*.

L_C 0.67μh, 12 turns #28 DCC, coil length ½″ on ¼″ diam. form. Adjust resonant frequency, using auxiliary 100-$\mu\mu$f capacitor, to 19.2 Mc*.

L_D 0.86μh, 16 turns #28 DCC, coil length ¾″ on a ¼″ diam. form. Adjust resonant frequency, using a 100-$\mu\mu$f auxiliary capacitor, to 17.1 Mc*.

Fig. 3. Either of these filters can be built to exact specification with tools and equipment that are at the amateur's disposal. Reasonably good results may be obtained even if each resonant circuit is *not* set to the design frequency, providing the coils are wound as specified. The filters shown are good, practical devices and a "cook-book" method of constructing them may be all that is required to eliminate specific interference conditions. The two-section filter is shown in *Fig.* 1, and the four-section filter is shown in *Fig.* 4. Note how the components are arranged to minimize coupling between coils.

In order to understand the operation of these filters and the simplified design information on the construction of high-pass filters capable of satisfying any requirement, a review of the basic principles of high-pass filter design is of considerable value.

Design Considerations

The following principles are involved in the selection of design parameters for high-pass filters:

1. The cutoff frequency of the filter should be as far as is practical from the pass-band frequencies.

2. The end sections of the filter should match the line. This match is obtained by utilizing the characteristic resistence of the line in the calculations, and by assuming a peak-attenuation frequency of 80 per cent of the design cutoff frequency.

3. The design cutoff frequency, once selected, should be used in the calculations for all sections of the filter.

4. The peak-attenuation frequencies of the intermediate sections should be selected to produce the greatest rejection for particular signals causing the most interference.

With these four principles in mind, let us select the design parameters. The cutoff frequency (f_{co}) will fall between 30 and 55 Mc, preferably nearer 30 than 55. The center of amateur activity in the 30-Mc region is 29 Mc; consequently the maximum attenuation of the end sections is set most advantageously at 29 Mc. If the peak-attenuation frequency, 29 Mc, is to be 80 per cent of the

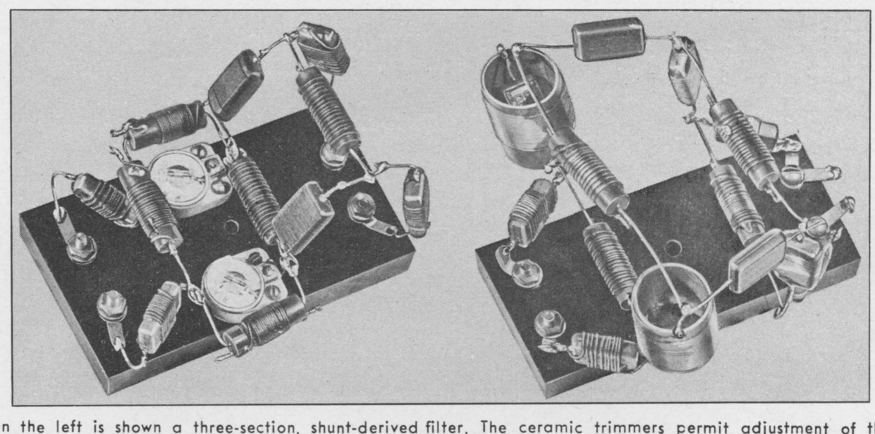


Fig. 4 On the left is shown a three-section, shunt-derived filter. The ceramic trimmers permit adjustment of the 27-Mc intermediate section after the filter has been installed in the TV set. The filter on the right is also a shunt-derived type, except that it has four sections. (Note that some of the coils are wound directly on the mica capacitors).

cutoff frequency, then f_{co} should be 36.25 Mc. Because most television sets use 300-ohm Twin Lead for antenna feeders, 300 ohms will be used for "R" in the sample calculations that follow.

Intermediate Sections

The intermediate sections can provide additional attenuation for 10- or 11-meter signals, and they can also be designed to reject signals from the lower frequency amateur bands. With one intermediate section set for 27 Mc, one for 14.2 Mc, and a third section designed to build up good rejection characteristics in the 1.75, 3.5, and 7 Mc bands, protection against signals from the most populous amateur bands can be obtained. The third intermediate section, the one that rejects the low-frequency amateur signals, is designed by utilizing "0 Mc" as the peak-attenuation frequency in the calculations.

The design parameters for the filter now can be listed in a table to assist in visualizing the arrangement. As a matter of fact, all of the important factors involved in the design of each section can be listed in tabular form. The first three lines of *Table I* show the items discussed thus far. These basic items must be used to determine the factors m and K which match the filter sections to each other and to the line.

Matching Factors

First of all, m is determined by the relation:

$$m = \sqrt{1 - \left(\frac{f_p}{f_{co}}\right)^2}$$

To save time, a curve (*Fig.* 5) has been

Table I — Filter Design Factors

	End Sections	Intermediate Sections			Units
Cutoff Freq. (f_{co})	36.25	36.25	36.25	36.25	Mc
Peak-Attenuation Freq. (f_p)	29	27	0	14.2	Mc
Characteristic Res. (R)	300	300	300	300	ohms
f_p/f_{co}	—	0.745	0	0.392	—
m (from *Fig.* 5)	—	0.67	1	0.92	—
K (from *Fig.* 6)	—	0.205	0	0.041	—
C_1 Shunt-derived filter, *Fig.* 8	48.8	22	14.7	15.9	μμf
L_1 " " " " "	0.62	1.6	open circuit	8.0	μh
L_2 " " " " "	2.2	2.0	1.3	1.4	μh
C_1 Series-derived filter, *Fig.* 7	13.7	34.8	short circuit	176	μμf
C_2 " " " " "	48.8	43.8	29.3	31.8	μμf
L_1 " " " " "	2.2	1.0	0.66	0.72	μh

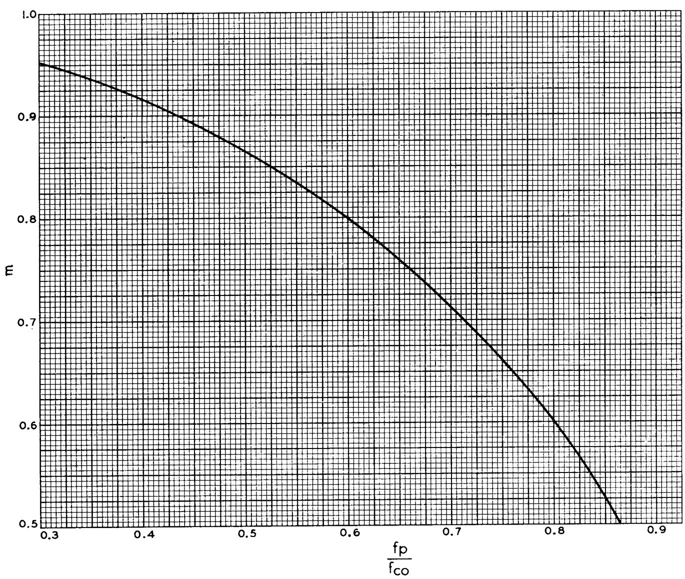


Fig. 5. The matching factor "m" for a high-pass filter section is obtained as follows: Divide the peak-attenuation frequency, f_p, of the section by the cutoff frequency, f_{co}. This quotient is then utilized to locate the value of "m" on this curve.

plotted which performs this operation. Simply read "m" opposite the value of f_p/f_{co} on the curve.

After "m" has been found, "K" can be calculated from:

$$K = \frac{1 - m^2}{4m}.$$

Time can also be saved by taking the value of "m" previously determined, and using *Fig.* 6 to determine K.

When the matching factors, m and K, have been determined, all the items that are necessary for calculating inductance and capacitance values for any filter section are available. All that remains to be done is to take the numerical values of the items determined above, insert them in the appropriate formulas (given in *Figs.* 7 and 8), and perform operations of simple multiplication and division. The results will be values of capacitance and inductance for all components in each filter section.

Formulas for High-Pass Filters

The formulas used in these computations have been simplified from the equations in T. E. Shea's text book, "Transmission Networks and Wave Filters." All of the elements of the original equations have been retained in the simplified formulas presented here, so that a correct match to the television set, to the TV feeder, and between filter sections is maintained.

The circuits and the formulas for designing series-derived, m-type filters are given in *Fig.* 7, and the formulas for shunt-derived, m-type filters are given in *Fig.* 8. A high-pass filter composed of series-derived sections requires fewer coils than a comparable filter composed of shunt-derived sections. To avoid complications, do not use both shunt-derived and series-derived sections in the same filter.

The amount of filtering required in a given installation determines the type of filter to be used and also the number of sections required. In outlying districts, a more effective high-pass filter may be required than would be needed for receivers nearer the TV station. Generally, receivers that are 150 feet or more away from the amateur transmitter can obtain sufficient rejection from a series-derived, two-section filter. For distances between 100 and 150 feet, two to four sections (series-derived) may be required. From experience with high-pass filters, at distances of less than 100 feet and with a transmitter running at 300-watts input, it has been found that three- or four-section shunt-derived filters are the most successful.

Perhaps, with shielding between sections and with the entire filter shielded, fewer sections would be required in the more elaborate units; however, it requires less time to build unshielded multiple-section filters than it does to build simple filters with shielding.

Component values for the two types of filters are listed in *Table I.* These values have been determined from the design formulas given in *Figs.* 7 and 8. Filters composed of one, two, or several sections can be designed from the data in *Table I,* and, in most cases, the only work required to design a good high-pass filter will be the selection of the appropriate component values

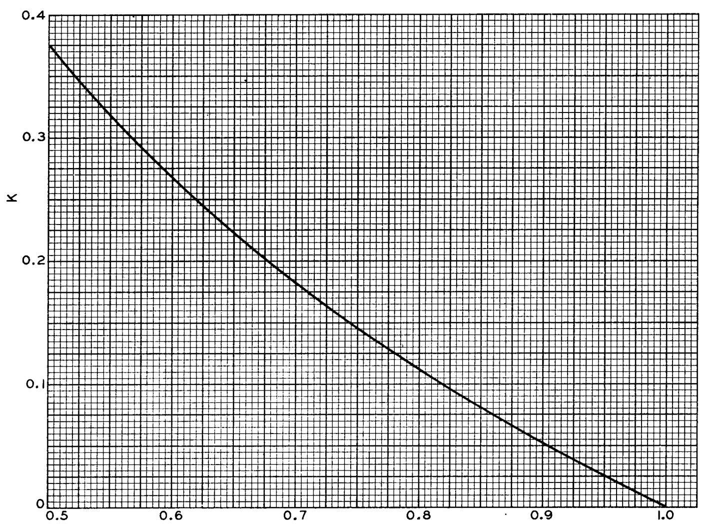


Fig. 6. After "m" is determined for a specific filter section, the corresponding value of "K" is obtained from this curve.

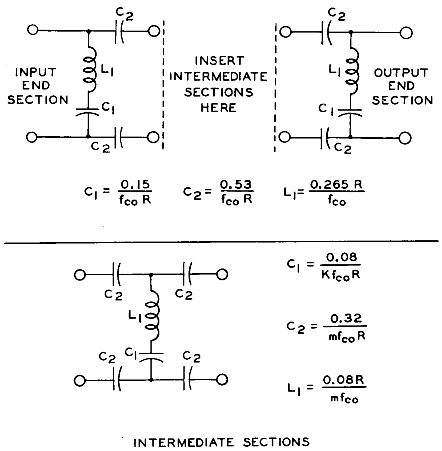


Fig. 7. Circuits and design formulas for series-derived, m-type, high-pass filters. The end sections shown are actually half-sections. They match the line of characteristic resistance, "R", and have maximum attenuation at 80% of the cutoff frequency, f_{co}. The intermediate sections require factors "m" and "K" from Figs. 5 and 6. Units are: C, in farads; L, in henries; frequency, in cps; and R, in ohms.

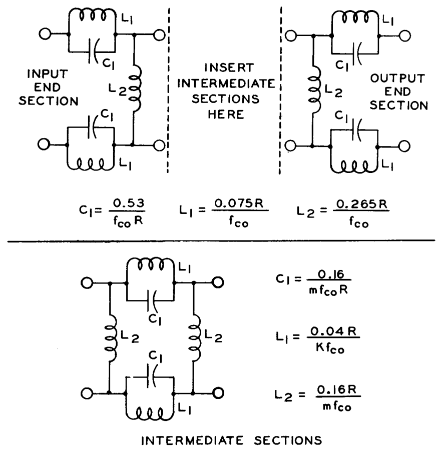


Fig. 8. Circuits and design formulas for shunt-derived, m-type, high-pass filters. The units and constants are described in the caption for Fig. 7. Shunt-derived filters have proved effective on TV receivers using 300-ohm feeders.

from the table. The set of sample calculations which follows may serve as a guide since occasionally a filter may be required for a television receiver operating from a 72-ohm coax, or perhaps a cutoff frequency other than 36.25 Mc may be desired. In such cases, the new values of R and f_{co} should be used with the proper formulas.

Sample Calculations

The following calculations are for a 300-ohm filter composed of shunt-derived, m-type sections:

End Sections (see *Fig.* 8)

$R = 300$, $f_{co} = 36.25$ Mc

$$C_1 = \frac{0.53}{f_{co}R} = \frac{0.53}{36.25(10^6)(300)}$$
$$= 48.8 \times 10^{-12} = 48.8\ \mu\mu f$$

$$L_1 = \frac{0.075\ R}{f_{co}} = \frac{0.075(300)}{36.25(10^6)}$$
$$= 0.62 \times 10^{-6} = 0.62\ \mu h$$

$$L_2 = \frac{0.265\ R}{f_{co}} = \frac{0.265(300)}{36.25(10^6)}$$
$$= 2.2 \times 10^{-6} = 2.2\ \mu h$$

Intermediate Section (*Fig.* 8)

$R = 300$, $f_{co} = 36.25$ Mc, $f_p = 27$ Mc, where

$$\frac{f_p}{f_{co}} = \frac{27}{36.25} = 0.745, m = 0.67 \text{ from } Fig.\ 5.$$

Since $m = 0.67$, $K = 0.205$ from *Fig.* 6.

$$C_1 = \frac{0.16}{mf_{co}\ R} = \frac{0.16}{0.67(36.25)(10^6)(300)}$$
$$= 22 \times 10^{-12} = 22\ \mu\mu f$$

$$L_1 = \frac{0.04\ R}{Kf_{co}} = \frac{0.04(300)}{0.21(36.25)(10^6)}$$
$$= 1.57 \times 10^{-6} = 1.6\ \mu h$$

$$L_2 = \frac{0.16\ R}{mf_{co}} = \frac{0.16(300)}{0.67(36.25)(10^6)}$$
$$= 1.98 \times 10^{-6} = 2.0\ \mu h$$

Intermediate Section (*Fig.* 8)

$R = 300$, $f_{co} = 36.25$ Mc, $f_p = 0$ Mc*, where

$$\frac{f_p}{f_{co}} = \frac{0}{36.25} = 0, m = 1, \text{ and } K = 0$$

$$C_1 = \frac{0.16}{mf_{co}\ R} = \frac{0.16}{1(36.25)(10^6)(300)}$$
$$= 14.7 \times 10^{-12} = 14.7\ \mu\mu f$$

$$L_1 = \frac{0.04\ R}{Kf_{co}} = \frac{0.04\ R}{0\ f_{co}} = \infty$$

$\therefore$ L_1 is equivalent to an open circuit.

$$L_2 = \frac{0.16\ R}{mf_{co}} = \frac{0.16(300)}{1(36.25)(10^6)}$$
$$= 1.32 \times 10^{-6} = 1.3\ \mu h$$

**This section builds up the attenuation capabilities of the filter at low frequencies. It aids in the rejection of the 1.75, 3.5 and 7-Mc amateur bands.*

An intermediate section for $f_p = 14.2$ Mc could be calculated in the same manner as for the 27-Mc section. Other sections could be used instead of those for 14 and 27 Mc if the interfering signal occurs at some other frequency.

C_1, C_2, C_7, C_8 50-$\mu\mu$f, Cornell-Dubilier Type 5W capacitors; ±5% tolerance.
C_5, C_6 15 $\mu\mu$f, Cornell-Dubilier Type 5W capacitors, ±10% tolerance.
C_3, C_4, 4-30 $\mu\mu$f, variable ceramic capacitor, Erie TS2A-N500.
L_1, L_2, L_7, L_8 0.62 μh, 10 turns #28 DCC wire close spaced, wound on the associated 50-$\mu\mu$f capacitor. Adjust inductance to produce a resonant frequency of 29 Mc* for each LC unit.
L_5, L_6 8.0 μh, 40 turns of #34 enamel wire close wound on associated 15-$\mu\mu$f capacitor. Adjust inductance to produce a resonant frequency of 14.2 Mc*.
L_3, L_4 1.6 μh, 17 turns of #28 DCC wire, coil length 3/8″ on 1/4″ diam. form. When the 4-30 $\mu\mu$f shunt capacitor is set at maximum capacitance, the resonant frequency of the combination should be 23 Mc.
L_A 1.05 μh, 16 turns #28 DCC, coil length 1/2″ on 1/4″ diam. form. Correct inductance* may be obtained by adjusting turns to resonate at 15.6 Mc using an auxiliary 100-$\mu\mu$f capacitor.
L_B 0.83 μh, 17 turns #28 DCC, coil length 7/8″ on 1/4″ diam. form. Correct inductance* may be obtained by adjusting turns to resonate at 17.4 Mc using an auxiliary 100-$\mu\mu$f capacitor.
L_C 0.86μh, 16 turns #28 DCC, coil length 3/4″ on 1/4″ diam. form. Adjust to resonate at 17.1 Mc. using an auxiliary 100-$\mu\mu$f capacitor.

*For resonace specification requirements, see note under Fig. 2.

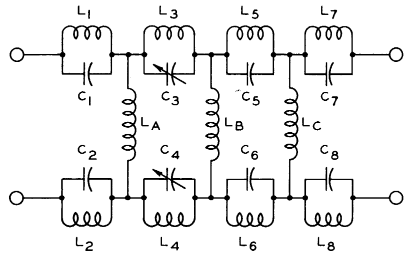


Fig. 10 Circuit diagram of a three-section, shunt-derived filter for 300-ohm TV feeder. The usable tuning range of the adjustable section is 25 to 30 Mc.

When the values for all of the components in the filters have been determined, the circuit may be diagrammed as shown in *Fig. 9*. The filter could actually be wired as indicated, but the circuit can be simplified by combining the inductance values which are in parallel. The basic operation is the same as that for determining the combined value of resistors in parallel. The combined value of inductances L_x and L_y in parallel is equal to

$$\frac{1}{L_x}+\frac{1}{L_y}=\frac{1}{L_{total}}$$

The four pairs of adjacent inductors in *Fig. 9* are combined to complete the sample calculations:

Coil A: $$\frac{1}{2.2}+\frac{1}{2.0}=\frac{1}{L_A}=\frac{2.2+2.0}{(2.2)(2.0)}$$
$$\therefore L_A = 1.05\ \mu h$$

Coil B: $$\frac{1}{2.0}+\frac{1}{1.3}=\frac{1}{L_B}=\frac{2.0+1.3}{(2.0)(1.3)}$$
$$\therefore L_B = 0.79\ \mu h$$

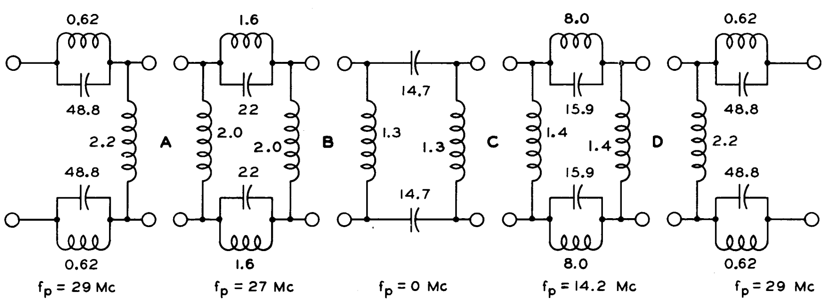
Coil C: $$\frac{1}{1.3}+\frac{1}{1.4}=\frac{1}{L_C}=\frac{1.3+1.4}{(1.3)(1.4)}$$
$$\therefore L_C = 0.67\ \mu h$$

Coil D: $$\frac{1}{1.4}+\frac{1}{2.2}=\frac{1}{L_D}=\frac{1.4+2.2}{(1.4)(2.2)}$$
$$\therefore L_D = 0.86\ \mu h$$

Mechanical Considerations

The final circuit for the four-section, shunt-derived filter is the one shown in *Fig. 3*. The four section-coupling coils calculated above were made by winding No. 28 DCC wire on 1/4-inch bakelite rods. The other coils were made by winding insulated wire around the capacitors as shown in the photograph of the completed filter. A higher Q is obtainable, however, if the coils are wound separately. As many of the coils as possible should be mounted at right angles to each other, and a reasonable physical separation should be kept between components to minimize coupling. The size of this filter is 3½″ x 2½″ x 2½″.

It is sometimes helpful to have one section in a high-pass filter that can be tuned after it has been installed so that adjustment for maximum rejection of a particular interfering signal can be made. A three-section filter having a pair of tunable components for adjusting the maximum rejection point between 25 and 30 Mc is shown in *Fig. 4*. This



INDUCTANCE VALUES ARE IN μh
CAPACITANCE VALUES ARE IN $\mu\mu$f

Fig. 9. The four sections of the shunt-derived filter should be drawn in this manner before the adjacent inductances are combined. After the inductances are combined, the circuit is identical to that of the filter given in Fig. 3.

filter has shunt-derived, m-type sections; its circuit is shown in *Fig.* 10.

When a tuned section is incorporated in a series-derived filter, the tuned resonant circuit is located in a shunt arm.

Series-Derived Filters

The arithmetic required for calculating component values for series-derived filters is similar to that shown in the shunt-derived example, the only difference being in the calculations needed for combining series capacitors. The formula

$$\frac{1}{C_x}+\frac{1}{C_y}=\frac{1}{C_{total}}$$

should be used if a minimum number of capacitors is to be employed.

The circuit for the two-section, series-derived, high-pass filter, *Fig.* 2, shows a tap at the center of the shunt coil. This tap is available for grounding the filter to the TV receiver chassis. Improved rejection has been obtained in some instances when a very short ground lead is run from this tap to the chassis. In many other installations, however, such a ground connection had no effect on the attenuation characteristic of the filter.

Filters for TV Coax

Thus far, only filters for balanced lines have been discussed. Unbalanced feeders of the coax type theoretically should require an unbalanced filter, a configuration in which all of the series-reactive components are placed in the circuit of the center conductor. In some cases, in particular those in which the signal to be rejected is reasonably weak, the unbalanced type of filter is adequate. Sometimes, however, a strong amateur signal also produces a standing wave on the outside of the TV coax, and the rf field that is present, in the region where the coax is connected to the receiver, couples energy to incompletely shielded components of the receiver. When this condition occurs, the outer conductor of the coax must be considered as a second wire, and it must therefore also be isolated from the receiver chassis by filter components. Such a filter would be a normal balanced line configuration, calculated for 72 ohms. A sketch of such an installation is shown in *Fig.* 11.

Where a TV coax shield is *not* coupling energy to the set components, an unbalanced-line filter is satisfactory. A small shield-can with coax fittings makes a good housing for an unbalanced line filter. The unit should be fastened to the TV chassis at a point where the "front-end" connection can be kept as short as possible.

Converting Balanced to Unbalanced Structures

Designing unbalanced filters from the formulas given in *Figs.* 7 and 8 is a simple matter. For 72-ohm coax, use 72 ohms for the value of "R" in the formulas and determine the values of all components, as in a balanced filter. The components that are connected across the transmission line in each section remain unchanged; the components in series with the transmission lines, however, must be lumped and placed in only one of the lines. The other line is a common ground to all sections of the filter. *Fig.* 12 illustrates the conversion as applied to individual filter sections.

The conversion of a balanced filter to an unbalanced filter can also take place after the sections of a balanced filter have been combined. An example of this method of conversion is shown in *Fig.* 13. The component values given in this figure are practical,

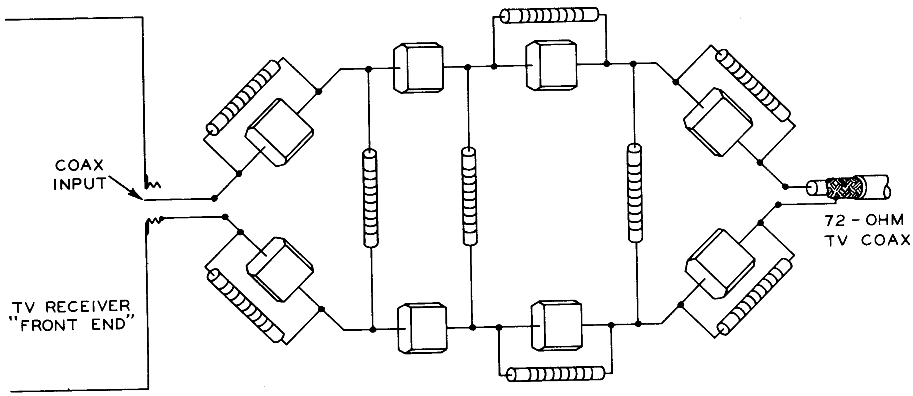


Fig. 11. Sketch showing how the inside and outside conductors of a coaxial transmission line are connected to a balanced 72-ohm, high-pass filter. This arrangement may be found necessary if an unbalanced-line filter is inadequate.

by other components in the filter section. The theoretical attenuation of each filter section at any given frequency can be calculated. Curves representing the attenuation characteristics of the individual sections listed in *Table I* are shown in *Fig.* 15.

When the attenuation is designated in decibels, it is easy to determine the combined effect of two or more sections of a filter because the attenuation values, at a given frequency can be added numerically. The sum of the values for all sections is the attenuation, at the given frequency, of the entire filter. The theoretical attenuation curves for three specific filters are shown in *Fig.* 16. When the attenuation in a given filter is estimated, keep in mind that for each 6 db of attenuation the voltage is cut in half. For instance, 24-db attenuation of a 1-volt signal would be equivalent to four progressive reductions of 50 per cent (0.5, 0.25, 0.125, and 0.0625), producing an output of 0.0625 volt.

If a particular receiver evidences interference when a 1-volt signal is introduced at the input to the tuner, some attenuation of that signal is required. Perhaps a filter capable of an attenuation of 24 db is adequate. Then, with such a filter, interference rejection would be satisfactory unless a 16-volt signal happened to be introduced. Sixteen volts is 24 db above one volt, so a 48-db filter would be required to provide adequate rejection of the stronger signal.

Sixteen volts may seem like a lot of rf to be available on a TV antenna, but voltages of this order of magnitude are not unusual when an amateur transmitter and a television receiver are within 15 or 20 feet of each other. As a matter of fact, a number of cases have been reported in which a neon bulb could be lighted at the TV receiver terminals when the amateur transmitter was on the air. Neon bulbs do not glow unless the potential applied is approximately 50 volts or higher.

Because television-antenna transmission lines do not match the antenna and the receiver at low frequencies, standing waves from the amateur signal are present on the line. A voltage-maximum point occasionally occurs at the receiver terminals, and when this condition exists, changing the length of the TV feeder may shift the location of the voltage maximum and reduce the rf at the receiver terminals. Adjustments of this type are helpful in minimizing the burden placed on a high-pass filter.

Other Paths for Interfering Signals

The installation of a booster also changes the effective length of a transmission line. Furthermore, after a booster has been installed, it may be found that there is an

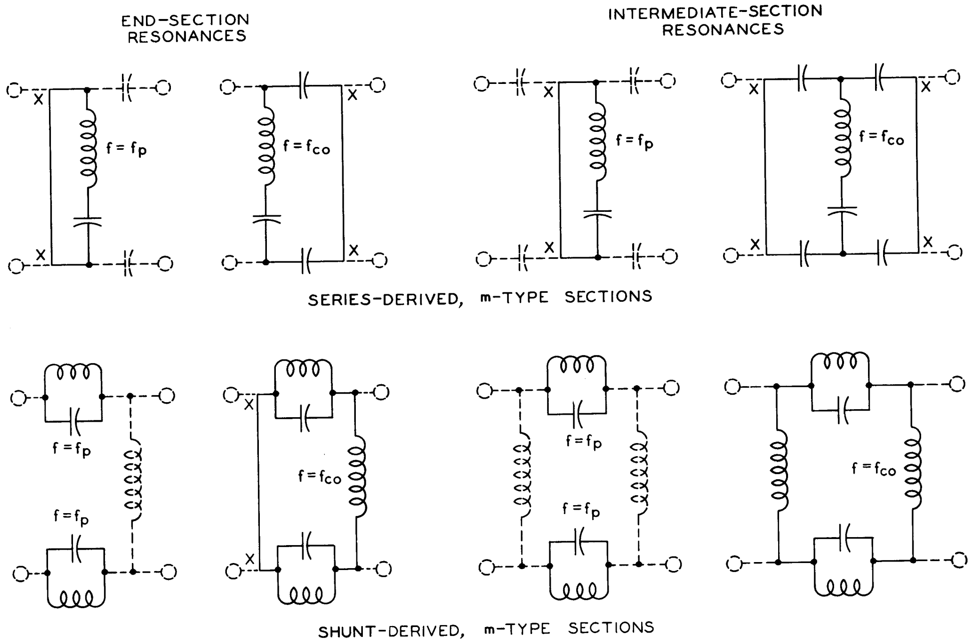


Fig. 14. The resonant circuits designated by solid lines are the combinations utilized to check the filter design calculations. Although not actually connected in a filter, lines x-x are shown to complete the resonant circuit when it is checked mathematically.

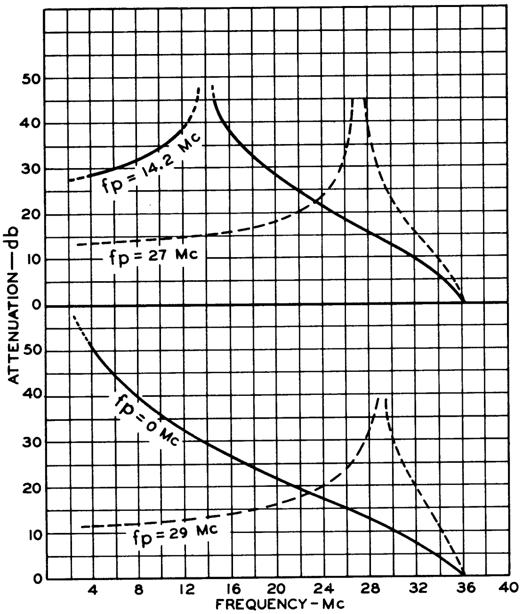


Fig. 15. These curves show the theoretical attenuation for individual sections of high-pass filters. The combined effect of the two end-sections is given in the 29-Mc curve. The other three curves are for intermediate sections. All of these sections were designed for a cutoff frequency of 36.25 Mc. There should be no attenuation above that frequency.

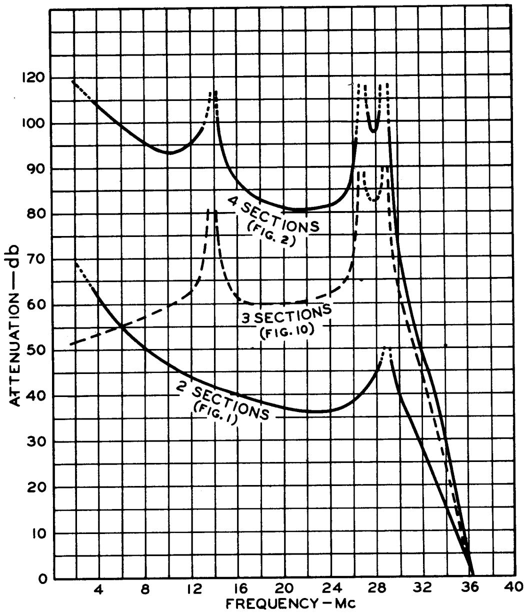


Fig. 16. Theoretical attenuation of several of the filters discussed in this article. In actual practice, these filters have been effective in rejecting amateur signals, and there has been no evidence of attenuation in the TV pass bands.

increase in interference due to the addition of one or more paths along which the amateur signal can enter the television receiver. Preventing an amateur fundamental from entering a booster is just as important as preventing the signal from entering a TV receiver, so a high-pass filter at the booster input is required. Sometimes a second high-pass filter is required between the booster and the receiver because the transmission line between the two units can pick up a strong amateur signal. The power-supply cord to the booster may also be involved in the transfer of an amateur fundamental to the TV receiver.

Supply-Line Filters

In some installations, the line cord to the TV receiver has been found to be a path along which the amateur signal enters the receiver. The amateur signal can get into the power line either by being fed directly into the ac line at the transmitter, if the rf filters in the power supply are inadequate, or by being picked up by the house wiring at the TV receiver location. The house wiring, including BX cable, may be a very effective receiving antenna.

Water, gas, and steam pipes are also capable of acting like receiving antennas. A "ground" wire connected from a TV receiver to a radiator may couple an amateur signal to the exposed components of a TV chassis. Direct pick-up by long leads in phonograph-radio TV consoles have also been found capable of introducing unwanted signals.

All long leads—line cords, speaker cables, etc. are capable of introducing a strong amateur signal to the vulnerable sections of a television receiver. RF chokes, placed in series with the leads, help in rejecting the undesired signals. A bypass capacitor connected at the point where the lead enters the chassis adds to the effectiveness of the choke in eliminating the interfering signal.

Conclusion

There are many variables involved in reducing interference in a television receiver. Each installation where interference is encountered may be slightly different from all the others. Fortunately, however, high-pass filters *will* solve almost all of the amateur interference problems attributable to receiver difficulties, and intelligent application of these devices should reduce to a minimum the number of unhappy situations that exist in the radio amateur's neighborhood.

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The next issue of HAM TIPS will contain a complete bibliography of TVI articles — a handy time-saving list. Don't miss it!

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HAM TIPS

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300-Watt Modulator with 811-A Push-Pull Output

By

George E. Jones, Jr., W2CBL*

HERE is a speech amplifier and modulator capable of delivering 300 watts of audio power through a multi-match modulation transformer into a wide range of class C loads. This unit is especially suitable for use with a transmitter such as the 500-watt rig which was designed by the author and described in a previous issue of HAM TIPS.**

The 811-A modulators are operated at zero bias and a plate voltage of 1250 volts. A 400-volt, 180-milliampere supply for the speech amplifier is included on the modulator chassis.

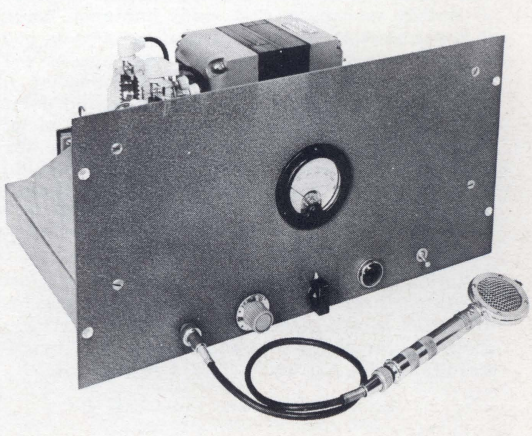
Circuit Considerations

A circuit diagram for the modulator is given in *Fig. 1.* The 6SJ7 amplifier stage is a high-gain stage (gain of approximately 180) designed to operate from the output of a high-impedance crystal or dynamic microphone. The input network (R_1C_1) has been designed to eliminate rf feedback, a difficulty often experienced when high-voltage rf fields are present. This network attenuates any rf voltage picked up in the input circuit before it reaches the grid of the 6SJ7.

One half of the first 6SN7 tube is used as an amplifier directly coupled to the second half of the tube, which is used for phase inversion, to obtain a push-pull signal for the following 6SN7. The cathode and plate resistors, R_{10} and R_{12}, respectively, should be matched resistors. The direct-coupled amplifier and the phase-inverter circuit is an adaptation of the well-known "Williamson Circuit." The second 6SN7 is a push-pull amplifier for driving push-pull, triode-connected, class A 807 drivers. The plate resistors R_{17} and R_{18}, in the push-pull 6SN7 stage, must be matched resistors to insure a balanced signal in the push-pull stages. Resistors having a tolerance of 5 per cent (gold band) are used for R_{10}, R_{12}, R_{17}, and R_{18}. For all other resistors, a tolerance of ± 10 per cent (silver band) is satisfactory.

Construction

The unit is constructed on a conventional 2 by 13 by 17-inch chassis and utilizes a 10½ by 19-inch rack-mounting front panel. Layout of the parts



is shown in the photographs. For operating convenience, all the necessary controls are located on the front panel. From left to right, in the above photograph, are shown the microphone input connector, the gain control R7, the cw-phone control switch SW_2, the power indicating pilot

*RCA Tube Dept., Harrison, N.J.

**May-August, 1948 (Vol. 8, No. 2)

TVI BIBLIOGRAPHY

Although it is generally agreed that TVI is a problem that will ultimately confront every amateur, most of us are inclined to avoid the subject until we are faced with a specific complant. The bibliography of articles on TVI on page 3 has been compiled to assist you in overcoming that apparently formidable obstacle to the continued enjoyment of operating your amateur station.

The listed articles contain many suggestions of value to the amateur who is planning to build a new transmitter. The probability of interference can be reduced appreciably if the transmitter design incorporates the recommended precautions to prevent the generation of spurious radiations. From the practical viewpoint, this approach is logical because it requires less effort than is needed for the application of elaborate corrective measures after the transmitter is built.

light PL_1, and the power-supply on-off switch SW_1. Meter M_1 is mounted in the center of the panel and is wired into the center tap of the transformer which supplies the 811-A filament power. The meter is placed at ground potential and indicates tube current (total grid and plate current) of the modulator tubes. The front panel and all controls are at ground potential for safety reasons.

The chassis layout is shown in *Fig. 2.* The power-supply components, viewed from above, are grouped at the upper left-hand side; the modulation transformer is mounted directly behind this supply. The speech amplifier starts at the upper right-hand side and continues to the rear of the chassis. This layout provides a very short, direct input connection to the speech amplifier, and isolates the high-gain amplifier stages from the power supply and modulator output transformer.

Wiring is simple and the 2-inch-deep chassis, shown in *Fig. 3,* provides easy access for wiring and soldering all components. The layout was chosen to minimize the possibility of oscillation, "motor boating," or hum pick-up; lead dressing and placement of parts are not critical. In order to obtain maximum gain with minimum hum, it is necessary to tie the ac and dc returns to one common ground point in the first stage of the speech amplifier. Microphone cable connector J_1 should be connected to the common ground point instead of being grounded directly to the metal chassis. This jack should be insulated from the chassis, and the input wiring of the 6SJ7 should be kept as short as possible to avoid extraneous pickup.

Adjustment and Operation

Variable resistor R_{29} in the power supply, just ahead of filter capacitor C_{14}, should be set for 400 volts at the output end of the second filter choke L_2. Ample decoupling is provided by capacitors C_4, C_8, C_9, and C_{11}, and resistors R_6, R_9, and R_{13} to minimize interstage coupling which could result in motor boating.

The 807 push-pull, triode-connected class A stage has a potentiometer (R_{20} accessible at the rear of the chassis) in the cathode circuit for balancing the plate currents of the two tubes. This adjustment is made at static (zero signal) conditions, and, once set, need not be changed unless the 807 tubes are changed. Test measurements on the completed speech amplifier show that positive grid current begins to flow in the second 6SN7 and the 807's at the same input-signal level, so the values of biasing resistors for the various stages are nearly optimum. In operation, the 811-A milliammeter will indicate about 125 ma on the peak swings of normal speech when the 1250-volt plate supply is off. When the plate supply is on, this current increases to approximately 450 ma on voice peaks for full output. With a sine-wave signal input, the 811-A's deliver approximately 300 watts into a fixed resistance load before the amplifier is overdriven (as evidenced by flattening of the sine-wave output voltage).

The driver transformer, T_1, is connected to obtain the maximum step-down ratio (primary-to-secondary) to provide for ample drive to the 811-A grids and also good regulation of the grid voltage for the class B stage.

The terminals on the multi-match transformer T_2, in the output, are connected so that the 9200-ohm, plate-to-plate load of the 811-A's is matched to the approximately 4000-ohm load of an 812-A push-pull, class C amplifier.

A suggested connection for the cw-phone control switch SW_2 is shown in *Fig. 1* with dotted-in connections to the class B and class C plate power-supply relays.

The amplifier is stable at full setting of the gain control. The frequency response characteristic of the amplifier and modulator is flat from 100 to 7,000 cps; it drops off only slightly from 7,000 to 10,000 cps.

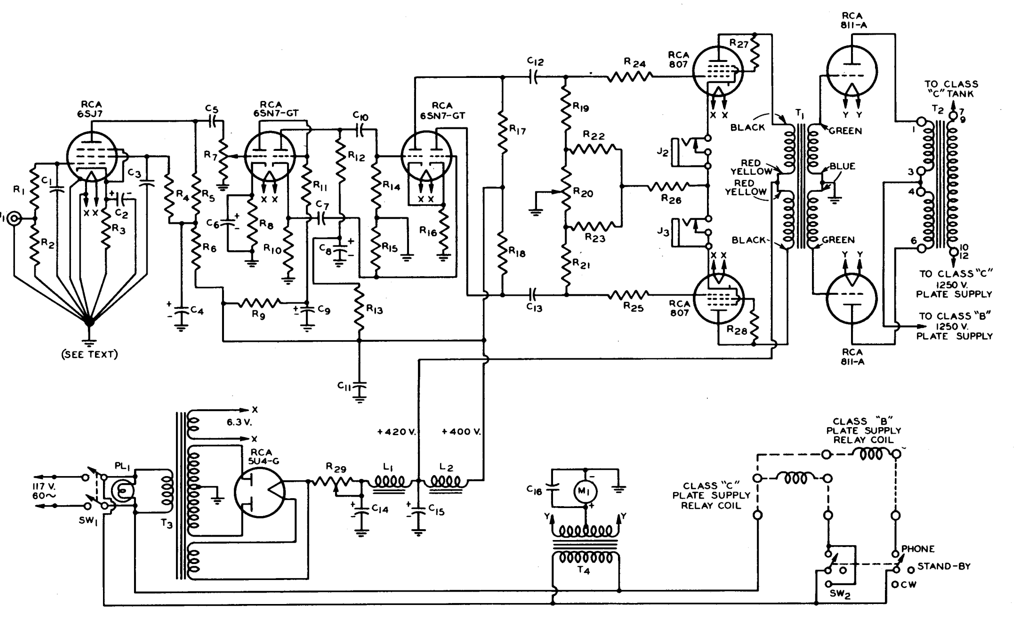


Fig. 1. Schematic diagram of the 300-watt modulator, speech amplifier, and power supply.

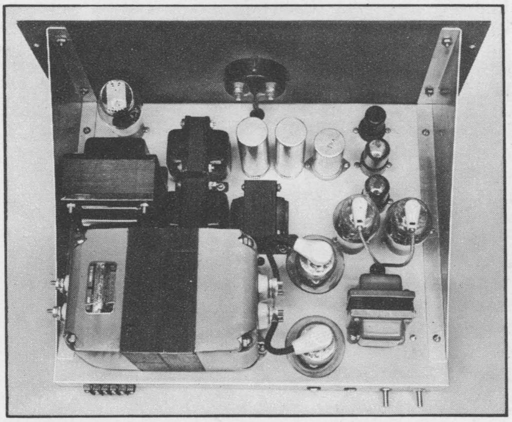


Fig. 2. Top view of the modulator; note that the well-planned layout of the modulator components permits the inclusion of a husky power supply on the same chassis.

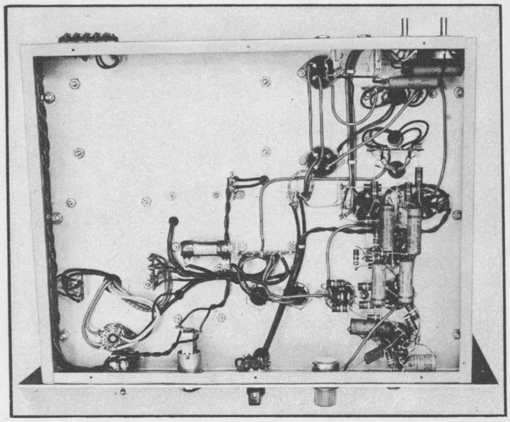


Fig. 3. Bottom view of the modulator; accent on simplicity and accessibility! Excellent performance, and no hum or feedback, without special dressing of leads or shielding!

PARTS LIST

C_1	0.0005 μf, mica, 600 v.
C_2	4 μf, electrolytic, 25 v.
C_3, C_7, C_{10}, C_{12} & C_{13}	0.1 μf, paper, 600 v.
C_4, C_8, C_9 & C_{11}	20 μf, electrolytic, 450 v.
C_5	0.005 μf, mica, 600 v.
C_6	40 μf, electrolytic, 25 v.
C_{14} & C_{15}	16 μf, electrolytic, 600 v.
C_{16}	0.01 μf, mica, 600 v.
J_1	Microphone-cable connector.
J_2 & J_3	Normally closed jack.
L_1 & L_2	Filter choke, 8 henrys at 150 ma, Thordarson T20C54 or equivalent.
M_1	Meter, 0-500 ma, Weston 301 or equivalent.
PL_1	Pilot lamp, 125 v., 3 watts.
R_1	100,000 ohms, ½ watt.
R_2	240,000 ohms, ½ watt.
R_3	2,000 ohms, 1 watt.
R_4	1.5 megohms, 1 watt.
R_5, R_{14}, & R_{15}	470,000 ohms, 1 watt.
R_6, & R_{11}	47,000 ohms, 1 watt.
R_7	Potentiometer, 0.5 megohm, 1 watt.
R_8	470 ohms, 1 watt.
R_9	30,000 ohms, 1 watt.
R_{10} & R_{12}	22,000 ohms, 1 watt (matched).
R_{13}	22,000 ohms, 1 watt.
R_{16}	820 ohms, 1 watt.
R_{17} & R_{18}	47,000 ohms, 1 watt (matched).
R_{19} & R_{21}	100,000 ohms, 1 watt.
R_{20}	Potentiometer, 100 ohms, 2 watts.
R_{22} & R_{23}	100 ohms, 10 watts.
R_{24} & R_{25}	1,000 ohms, 1 watt.
R_{26}	330 ohms, 10 watts.
R_{27} & R_{28}	100 ohms, 2 watts.
R_{29}	Adjustable, 100 ohms, 25 watts.
SW_1	DPST toggle switch.
SW_2	Double-pole triple-throw switch.
T_1	Driver transformer, primary to ½ secondary (5:1), Thordarson 20D82 or equivalent.
T_2	Multi-match modulation transformer, Thordarson 21M64 or equivalent.
T_3	Power transformer, 400-0-400 v, 200 ma; 5 v, 3 amp; 6.3 v, 5 amp, Thordarson TS24R07-U or equivalent.
T_4	Filament Transformer, 6.3 v at 10 amp, Thordarson T21F12 or equivalent.

TVI BIBLIOGRAPHY

A comprehensive listing of articles on TVI and related topics that have appeared since 1946. Although the articles appearing in the non-amateur publications contain only minor references to the amateur and TVI, they have been included to supply the advanced amateur with a complete set of references. A few articles on interference from sources other than amateur transmitters as well as some editorials have been listed. Radio amateur groups will find the editorial articles valuable references for discussions. Note that the articles are listed in chronological order; this has been done to facilitate retrospection, and to permit easy cross reference to TV reception techniques and improvements.

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HAM TIPS

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Volume XI, No. 1 Spring, 1951

Compact 2-Meter Civil-Defense Transmitter Employs RCA Miniatures and Popular 2E26

By

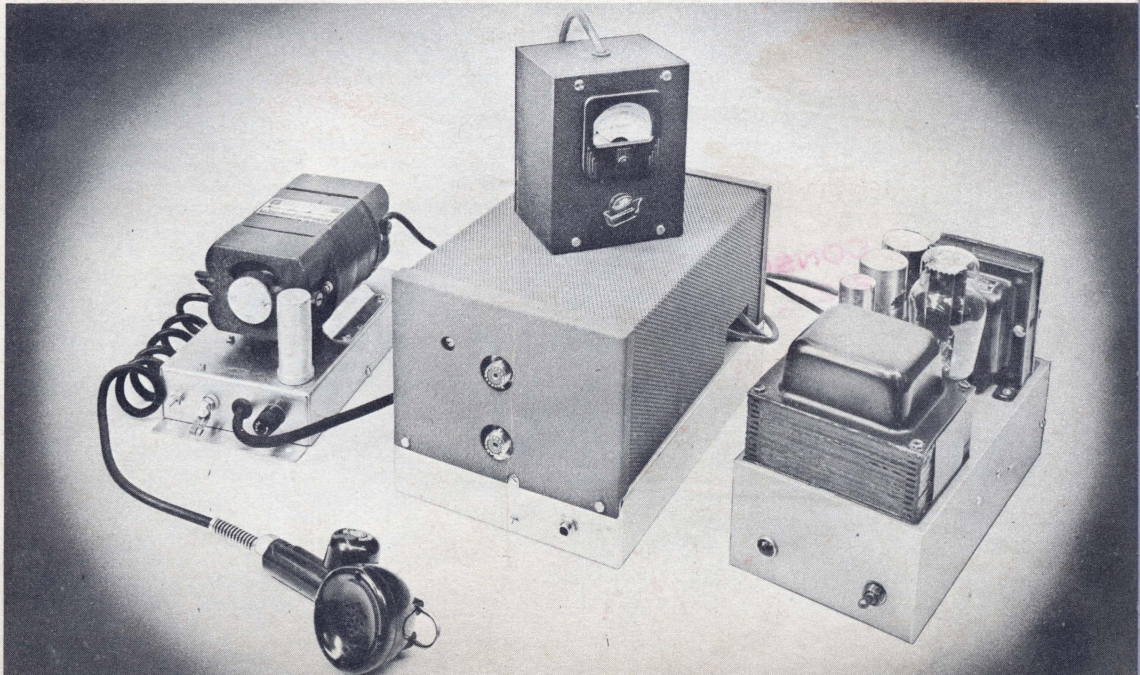
George D. Hanchett, Jr., W2YM*

When the FCC reserved sections of the two-meter and other bands for Civil-Defense operations in the event of war, public-spirited amateurs recognized the need for compact mobile and fixed-station equipment. In order to help fill this need, the transmitter described in this article was designed and constructed. This versatile two-meter transmitter meets the requirements of extreme reliability, minimum stand-by power consumption, ease of adjustment, and portability. It may be operated either from a 117-volt ac line or from a 6-volt storage battery; this transmitter provides an output of approximately 10 watts.

As SHOWN in the schematic diagram on *pg. 4*, a 6AK6 is employed as a crystal oscillator-tripler stage. Starting with an 8-Mc crystal, this stage provides a 24-Mc signal to the second 6AK6 which triples to 72 megacycles. A 5763 miniature beam-power amplifier is used as a doubler and a 2E26 operates as the final amplifier at 144 megacycles. For maximum power efficiency, a 1635 is used as a class B modulator. A 6N7-GT may be employed to obtain the same modulator output, but the 1635 has the advantage of requiring less heater power and a lower zero-signal plate current. The first audio amplifier utilizes one half of

**RCA Tube Dept., Harrison, N. J.*

Fig. 1. A compact Civil-Defense transmitter for fixed-station or mobile operation.



a 12AU7 as a grounded-grid stage to obtain a good match to the carbon microphone, and also to provide a convenient source of voltage for the microphone.

Meter Circuit

Metering the grid circuits of the frequency multipliers and the final amplifier, and the plate circuits of both the final amplifier and the class B modulator is accomplished by means of an external test meter. This arrangement permits the use of a single meter for adjusting all of the transmitters in a Civil-Defense network.*

As shown in *Fig. 2,* the test-meter circuit consists of a 0-1 ma meter, a two-section six-position switch, and two resistors. Connection of the test meter to the transmitter is made by means of a cable and plug.

When the meter switch is set to any one of the first three positions shown in *Table I,* the 3,900-ohm multiplier resistor and the milliammeter are connected in series between ground and a point on a voltage divider in the grid circuit. The meter deflection is proportional to the flow of grid current.

In positions 4 and 5 of the meter switch, the meter and the 910-ohm resistor, in series, are connected across a 10-ohm shunt (R_{23} for position 4, or R_{22} for position 5) to indicate the final-amplifier or modulator plate current, respectively. The test meter is connected between ground and a 1N34 rectifier in the antenna-coupling circuit in position 6 of the meter switch.

Construction

The transmitter is constructed on a 7 by 11 by 2-inch chassis; it is so arranged that the rf section is on one side of the chassis (refer to *Fig. 3*) and the modulator and power plugs on the other side. Separating these two sections, on the underside of the chassis, is a strip of aluminum to which a resistor board is fastened. All of the resistors, with the exception of the 5763 grid resistor, R_{10}, are mounted on this board. Such mechanical support of the resistors provides the necessary ruggedness for mobile operation.

By-passing in the frequency multipliers and the final amplifier is accomplished with single-and dual-section ceramic capacitors. The metering leads are brought to an octal meter jack for connection to the external test meter. Transformer T_1 is a standard RCA TV sound if unit, 206K1, and L_1 is a stagger-tuned video if coil, 202L1.

The arrangement of the components in the output tank circuit is shown in *Fig. 5.* The bracket for this tank circuit is made from a 4 by 5-inch piece of aluminum. The output link coil is connected to a coaxial relay so that in the non-energized position, the antenna will be connected to the associated receiver.

**Each unmetered transmitter may be monitored during transmission by a pair of headphones connected to monitor jack J5 in the antenna-coupling circuit.*

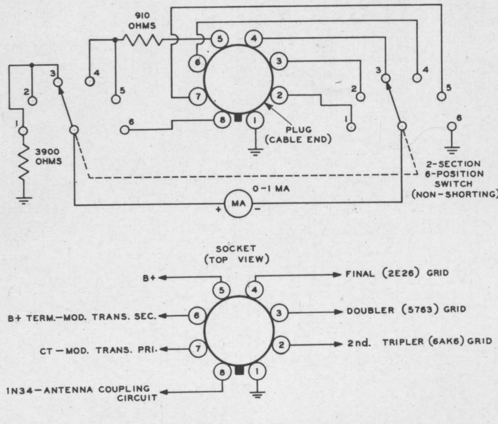


Fig. 2. Test-meter circuit.

Table I — Test-Meter Calibration Data

Switch Position	Indication	Full-scale Deflection
1	2nd tripler (6AK6) grid current	5 ma
2	Doubler (5763) grid current	5 ma
3	Final (2E26) grid current	5 ma
4	Final (2E26) plate current	100 ma
5	Class B mod. plate current	100 ma
6	RF power output	15 watts

Adjustment

The tuning of the transmitter is a simple process. With only the two 6AK6's in place, connect the transmitter to the 300-volt supply. Connect the test meter to the unit and set the selector switch to the second tripler-grid position. Vary the inductance of L_1 to obtain oscillation, and then adjust the primary and secondary of T_1 for maximum meter deflection. The grid current of the second 6AK6 should be approximately 2 ma.

Insert the 5763 into the transmitter and adjust L_2 to resonance as indicated by maximum 5763 grid current when the test meter is set in position 2. At resonance the grid current of the 5763 should be approximately 1 ma. Adjust-

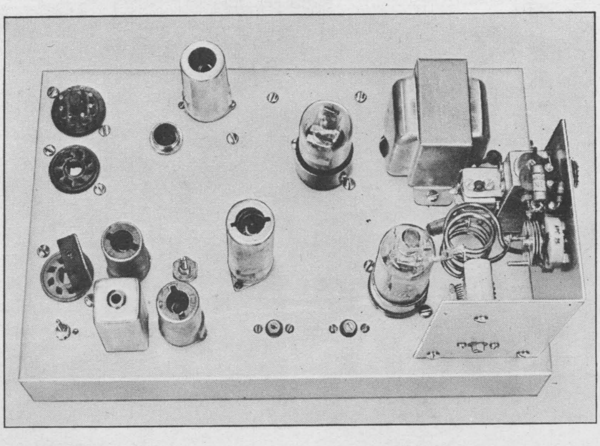


Fig. 3. Top view of the transmitter.

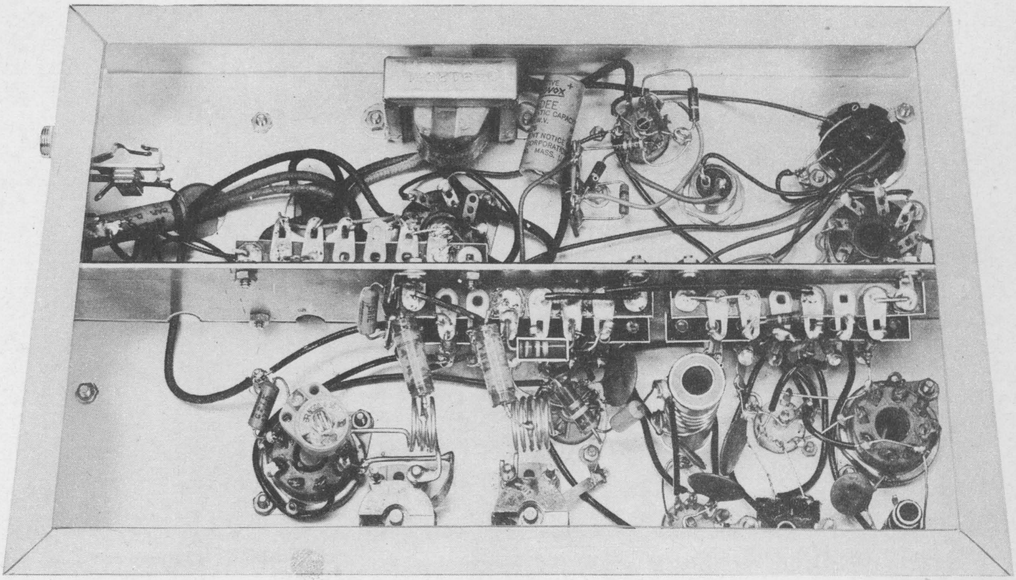


Fig. 4. Bottom view of the transmitter. The resistor board provides the necessary mechanical support for mobile operation.

ment of L_2 should be made as rapidly as possible, so that the 5763 plate circuit (which will probably not be in resonance) does not draw excessive current for a sustained period.

Switch the test meter to the 2E26 grid position (3) and plug in the 2E26. To protect the 2E26 during the initial tune-up, disconnect the series screen resistor, R_{16}, from the plate supply. Then adjust C_{14} and C_{15} for maximum grid current in the 2E26; the 2E26 grid current should be approximately 1.5 to 2.0 ma.

At this point in the initial tuning procedure, the final amplifier should be neutralized as follows: rotate C_{20} through its entire range and observe the downward kick of the test meter (switch set in position 3, the 2E26 grid-current position). Then adjust neutralizing capacitor C_N until the downward deflection of the meter needle is minimized when C_{20} is rotated through its range. Reconnect the screen-grid resistor to the plate supply and set the meter selector switch to the 2E26 plate-current position (4). Capacitor C_{20} should then be adjusted for resonance.

After these adjustments have been made, connect the antenna to the transmitter and set the test meter switch to the output position (6). Capacitor C_{21} should be adjusted for maximum output. When a 52-ohm coax cable is used, a meter reading of approximately 0.4 ma indicates 10 watts of rf power. Finally, readjust L_1, T_1 C_{14}, C_{15}, and C_{20} for maximum power output.

The 1635 class B modulator tube and the 12AU7 speech-amplifier tube should then be plugged in and the microphone connected to the transmitter.

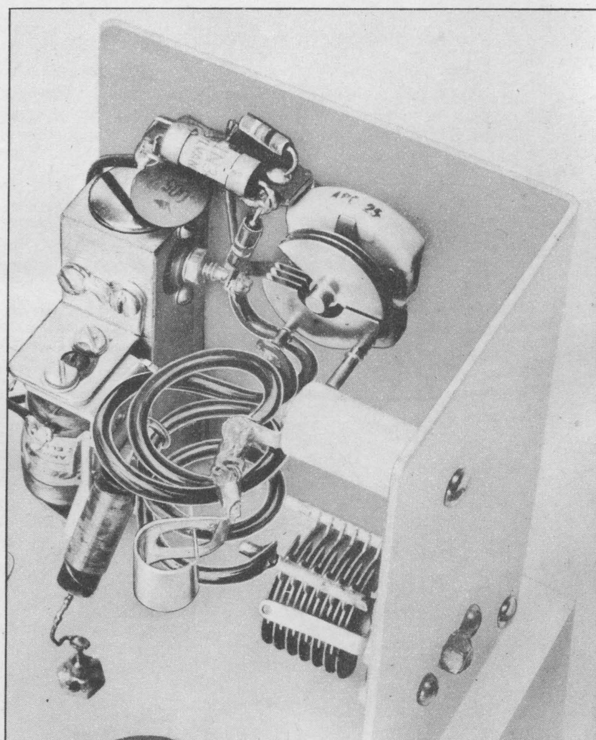
AC Power Supply

The power supply for ac operation is shown to the right of the transmitter unit in *Fig. 1;* the schematic diagram for this supply is shown in *Fig. 7.* This supply is constructed on a 5 by 10 by 3-inch chassis. It employs a conventional full-wave rectifier and filter circuit, plus a selenium rectifier which supplies 6 volts dc for relay operation. The relay shown in *Fig. 7* is a control relay which simultaneously grounds the center tap of the high-voltage winding of the power transformer and applies energizing voltage to the antenna relay when the microphone switch is closed.

Genemotor Power Supply

For mobile and emergency operation, the power unit shown in the upper left-hand corner of *Fig. 1* should be connected to the octal chassis

Fig. 5. Closeup view of the tank circuit.



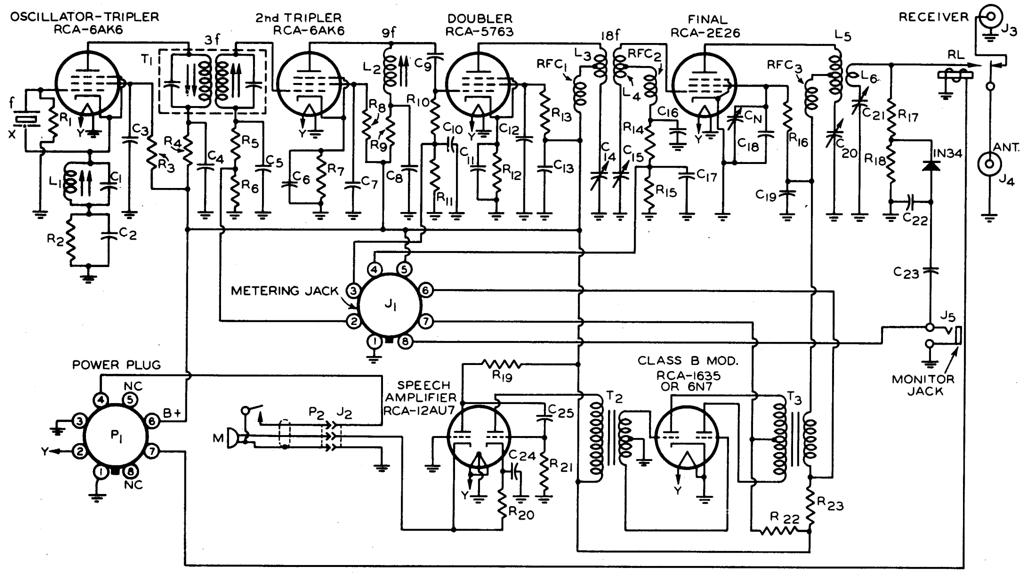


Fig. 6. Schematic diagram of the transmitter.

connector P_1, located on the transmitter. This supply employs a Genemotor which operates from a 6-volt storage battery to provide a plate voltage of 300 volts. The output of the Genemotor is filtered with a single 4-μf capacitor. A control relay is also included in this supply as shown in the schematic diagram, *Fig. 8.* When the microphone switch is pressed, this relay connects the ungrounded input terminal of the Genemotor to the "hot" side of the storage battery, and simultaneously applies energizing voltage to the antenna relay. A 5 by 9½ by 2-inch chassis is required for the construction of this power supply.

Installation Notes (Mobile Operation)

For mobile operation, the transmitter and the Genemotor supply should be fastened securely to a shock-mounted support. A piece of ¾-inch plywood and four shock mounts will serve as a simple vibration-proof mounting.

Connection to the car battery should be made through a heavy conductor to minimize voltage drop. If the transmitter is installed in the trunk of the car, a No. 4 flexible cable is recommended; a No. 6 conductor is adequate if the length is four feet or less.

Check the polarity of the auto battery and determine the polarity of the grounded terminal. As shown in *Fig. 8,* the negative input terminal of the Genemotor is grounded. *If the positive terminal on the battery is grounded, reverse the input connections to the Genemotor.*

Since the details of the mobile installation will vary with the type of vehicle and also with individual preferences, the control circuit for the application of heater voltage has not been included in the dc supply. Heater voltage should be controlled by means of a 6-volt, SPST relay with ¼-inch contacts connected in series with the "A hot" input terminal of the Genemotor supply and the ungrounded battery terminal. Energizing voltage to the coil of this relay may be controlled by a SPST toggle switch located at the operating position.

Operation

With the ac power supply connected to P_1, heater voltage will be applied to the tubes in the transmitter when the power supply switch is turned on. Closing the microphone push-to-talk switch will simultaneously apply plate voltage to the transmitter tubes and cause the antenna-transfer relay to operate, regardless of the power supply employed.

Table II — Currents and Voltages for Normal Operation*

Meter Indication	Oscillator Tripler (6AK6)	Second Tripler (6AK6)	Doubler (5763)	Final (2E26)	AF Amp (½ 12AU7)	Driver (½ 12AU7)	Modulator (1635)
E_b (v)	275	265	300	300	300	300	300
I_b (ma)	12	15	35	60	4	7	6 (min.) 40 (max.)
I_{c2} (ma)	2.3	3.0	2.5	5.0	—	—	—
E_{c2} (v)	195	165	250	200	—	—	—
I_{c1} (ma)	0.7	2	0.9	1.6	—	—	—
E_k (v)	12	20	1.5	0	4	11	0

* *For rf output of 10 watts.*

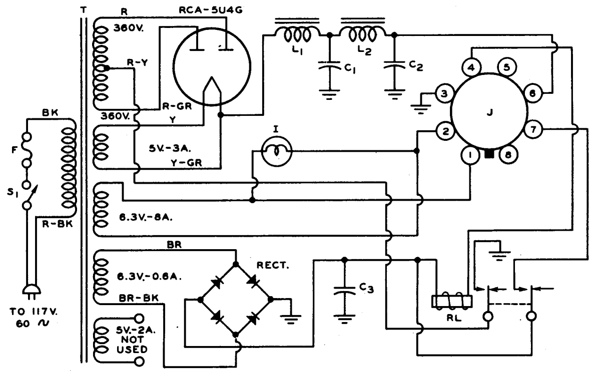


Fig. 7. Schematic diagram of the power supply for the fixed-station installation.

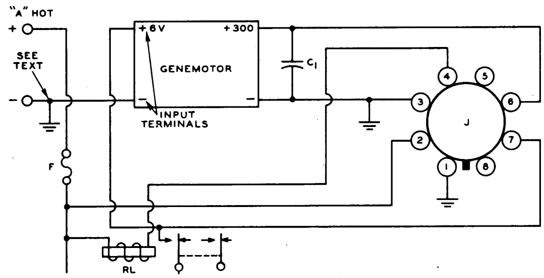


Fig. 8. Schematic diagram of Genemotor power supply for the mobile installation.

Transmitter

C_1 100 $\mu\mu$f.
C_2 0.005 μf, disc ceramic.
C_3, C_4 Twin 0.004 μf, disc ceramic.
C_5 0.005 μf, disc ceramic.
C_6, C_7 Twin 0.004 μf, disc ceramic.
C_8 0.005 μf, disc ceramic.
C_9 10 $\mu\mu$f.
C_{10} 0.005 μf, disc ceramic.
C_{11}, C_{12} Twin 0.004 μf, disc ceramic.
C_{13} 0.005 μf, disc ceramic.
C_{14} 25 $\mu\mu$f, air padding.
C_{15} 25 $\mu\mu$f, air padding.
C_{16} 100 $\mu\mu$f.
C_{17} 0.005 μf, disc ceramic.
C_{18} 47 $\mu\mu$f.
C_{19} 470 $\mu\mu$f, feed-through type.
C_{20} 25 $\mu\mu$f, air padding.
C_{21} 25 $\mu\mu$f, air padding.
C_{22} 0.005 μf, disc ceramic.
C_{23} 0.01 μf, 400 wv.
C_{24} 25 μf, 25 wv, electrolytic.
C_{25} 0.005 μf, disc ceramic.
C_N 4-30 $\mu\mu$f, ceramic.

J_1 8-pin octal socket.
J_2 Amphenol connector PC2F.
J_3 Coaxial connector type N } part of coax relay R_L.
J_4 Coaxial connector type N }
J_5 Phone jack.

L_1 RCA 202L1, TV picture if coil.
L_2 5 turns 14E on 1/2-in. diam, spaced to fill winding space of 11/16 in. on National XR50 form.
L_3 5 turns 14E on 1/2-in. diam; space between turns equal to wire diam.
L_4 3 turns 14E on 1/2-in. diam; space between turns equal to wire diam.
L_5 3 turns 10E on 3/4-in. diam; spaced to occupy 1 1/2 in.
L_6 Single turn 10E on 1-in. diam.

M Carbon microphone with "push-to-talk" switch.

P_1 8-pin octal plug.
P_2 Amphenol connector MC2M.

R_1 100,000 ohms, 1/2 watt.
R_2 1,000 ohms, 1/2 watt.
R_3 47,000 ohms, 1/2 watt.
R_4 1,000 ohms, 1/2 watt.
R_5 33,000 ohms, 1/2 watt.
R_6 1,000 ohms, 1/2 watt.
R_7 1,000 ohms, 1/2 watt.
R_8 47,000 ohms, 1/2 watt.
R_9 1,000 ohms, 1/2 watt.
R_{10} 82,000 ohms, 1 watt.
R_{11} 1,000 ohms, 1/2 watt.
R_{12} 68 ohms, 1/2 watt.
R_{13} 22,000 ohms, 1 watt
R_{14} 33,000 ohms, 1 watt.
R_{15} 1,000 ohms, 1/2 watt.
R_{16} 20,000 ohms, 1 watt.
R_{17} 15,000 ohms, 1/2 watt.
R_{18} 10,000 ohms, 1/2 watt.
R_{19} 47,000 ohms, 1/2 watt.
R_{20} 1,000 ohms, 1/2 watt.
R_{21} 470,000 ohms, 1/2 watt.
R_{22}, R_{23} 10 ohms, 1/2 watt.

RFC_1, RFC_2, RFC_3 { 40-in. length of 32E wound on 1/4-in. diam. form.

R_L Advance 8500, 6-volt type or equivalent.

T_1 RCA 206K1, TV sound if transformer.
T_2 Thordarson T20D76 or equivalent.
T_3 Thordarson T21M52 or equivalent.

AC Power Supply

C_1 40 μf, 450 wv, electrolytic.
C_2 80 μf, 450 wv, electrolytic.
C_3 3,000 μf, 15 wv, electrolytic.
F 5-ampere fuse.
I 6-v, 150-ma pilot lamp.
J 8-contact octal socket.
L_1 Choke, 3 henrys at 225 ma, Peerless C-315-X or equivalent.
L_2 Choke, 5 henrys at 200 ma, Stancor C-1646 or equivalent.
R_L Relay, 6v (dc), Advance 500 or equivalent.
RECT Selenium rectifier, 600 ma, 25v, Federal 1017.
S_1 SPST Toggle Switch.
T Power transformer, RCA 201T8.

Genemotor Power Supply

C_1 4 μf, 450 wv, electrolytic.
F 30-ampere fuse.
G Carter Genemotor 325-A or equivalent: input 6v, 21 amp; output 300v, 250 ma.
J 8-contact octal socket.
R_L Relay, 6v(dc), Advance 500.

Keying the Beam-Power Phone Final*

By

J. H. Owens, W2FTW**

By the installation of a single control tube and a few resistors, practically any beam-power phone transmitter can be converted for cw operation. And when the key is down, the final is just as suitable for plate-and-screen modulation as it was before the keying system was added.

In addition to providing a clean-cut cw signal that is free from chirps, thumps, and key clicks, this unique system offers worthwhile advantages over some of the keying systems presently in use.

BASICALLY, the new method is simply an adaptation of the well-known cathode-return keying system popularly used in triode finals. It differs by the use of a unique method of preventing the screen-grid voltage from exceeding tube ratings when the key is in the up position. With this system, the screen-grid voltage is reduced below the cathode voltage, thereby completely cutting off the plate current in the final amplifier; consequently, the back-wave signal is not transmitted.

For purposes of illustration, this keying system is described here as applied to a typical low-power final employing a single 807. The circuit diagram is shown in *Fig. 1.* A 6AQ5 miniature beam-power tube is used in the control-tube circuit.

The dc plate resistance of the 6AQ5 can be made either very low or practically infinite, depending upon whether the key is up or down, respectively. Because the plate of the 6AQ5 is tied directly to the screen-grid of the final-amplifier tube, the 6AQ5 performs electronically and instantly the service of a relay without the delay, sparking, and other difficulties sometimes encountered with relays in high-speed circuits.

The system is also applicable to both phone and cw transmitters employing tetrodes or pentodes.

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Key-down Position

The operation can best be understood by examining the circuit in the key-down position. The cathode of the final is at ground potential, being bypassed for rf through C_2, while the dc return is through R_5 (a few ohms) and the key. The plate current of the 6AQ5 is practically cut off because the screen-grid of this tube is connected to the same ground-return circuit. The control-grid of the 6AQ5 is connected through an isolating and filtering resistor to the grid side of the grid-bias resistor of the final amplifier, a negative-voltage point. The combined effects of high negative bias on the control-grid and substantially ground potential on the screen-grid raise the dc plate resistance of the 6AQ5 to near infinity. Thus, for all practical purposes, the 6AQ5 has absolutely no effect on the final amplifier which operates as if the control-tube were out of the circuit. Obviously, when the key is down, the final amplifier can be plate-and-screen modulated the same as before the control circuit was installed.

Key-up Position

When the key is in the up position, entirely different conditions prevail. The open key removes the dc ground return from the final-amplifier cathode and the 6AQ5 screen-grid, and both of these electrodes become positive as a result of voltage being applied through R_3. At the same time, the control-grid of the 6AQ5 becomes slightly positive because it is connected to the final amplifier cathode through isolating resistor R_2, the grid-bias resistor R_{11}, and the grid milliammeter M_1. Although grid current continues to flow through the final amplifier grid-bias resistor, the negative voltage across this resistor is con-

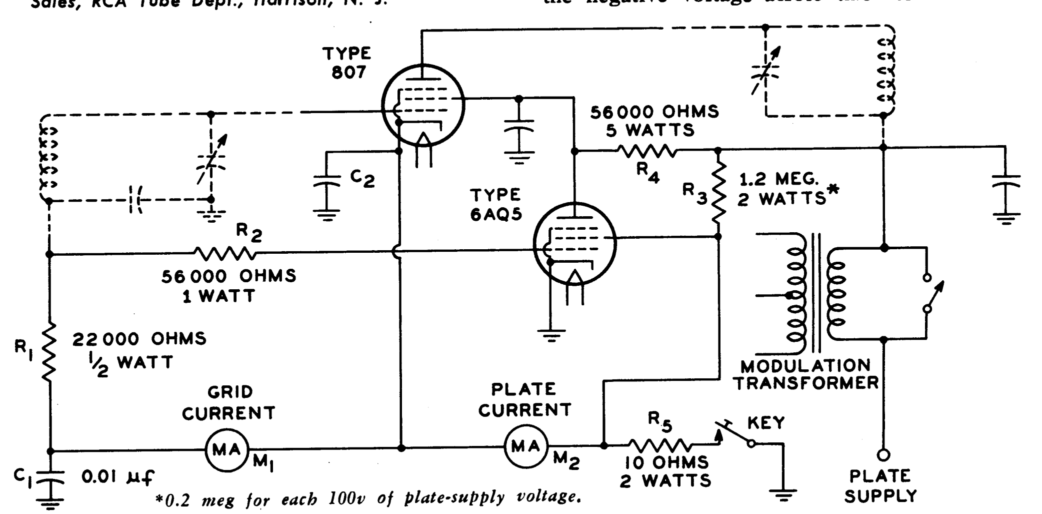

Fig. 1. Schematic diagram of a typical beam-power phone final and the 6AQ5 control tube which prevents excessive screen voltage on the 807 final in the key-up position.

siderably less than the positive voltage between the final-amplifier cathode and ground; therefore, the net potential at the top of the grid-bias resistor is positive.

This voltage is applied to the control-grid of the 6AQ5 through isolating resistor R_2, but the low resistance of the positive 6AQ5 grid and the high resistance of the isolating resistor cause a relatively large voltage drop; hence the grid of the 6AQ5 is slightly positive. The combined effects of slightly positive bias on the control-grid, and the substantial positive voltage on the screen-grid reduce the dc plate resistance of the 6AQ5 to a low value. The plate of the 6AQ5, being tied to the final-amplifier screen grid, puts a heavier load on the screen-grid dropping resistor R_4 than does the screen grid of the final amplifier; therefore, the voltage on this screen is greatly reduced when the key is in the up position. In fact, it is reduced below the cathode voltage, and this, plus the negative bias applied between cathode and the control-grid, serves to cut off the final-amplifier plate current. The overall effect is that the screen-grid of the final amplifier is protected and the rf signal is interrupted.

Circuit Details

Note the location of the grid and plate meters in the circuit. This arrangement provides the least amount of interaction without having the plate-current meter in the high-voltage circuit. As connected, milliammeter M_2 indicates the sum of the plate and screen currents. The grid meter, M_1, indicates the dc grid current. (As previously mentioned, grid current continues to flow when the key is up.) The grid current is practically the same when the key is down.

The values for the three added resistors (R_2, R_3, and R_5) are given in the schematic diagram; actual values are not critical. Resistor R_2 is simply an isolating resistor to keep rf off the 6AQ5 control-grid. Resistor R_5 is a key-click suppressor. Resistor R_3 applies positive voltage to the final cathode and 6AQ5 screen-grid; its value may be halved or doubled for experimental trials. Resistor R_4 is the screen-grid dropping resistor.

A 6AQ5 keying tube is satisfactory for an 807 or 829-B. If one or two 813's are used in the final rf amplifier, a 6V6-GT or 6F6-G should be substituted for the 6AQ5. The actual resistance and power rating of R_3 will vary with the plate-supply voltage.

It is good practice to short out the secondary of the modulation transformer when a phone transmitter is keyed. Switch S_1 is included in the circuit for this purpose.

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A comprehensive listing of articles on TVI and related topics. Although the articles appearing in the non-amateur publications contain only brief mention of the amateur and TVI, they have been included to supply the advanced amateur with a complete set of references. A few important articles on interference from sources other than amateur transmitters as well as some editorials have been listed. Radio amateur groups will find the editorial articles valuable references for discussions. Note that the articles are listed in chronological order; this has been done to facilitate retrospection, and to permit easy cross reference to TV reception techniques and improvements.

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HAM TIPS

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Volume XI, No. 2 Summer, 1951

"The Big Hunt"

De-TVIing a 600-Watt, 14-Mc Transmitter

By

C. A. West, W2IYG†

After considering the great deal of time and effort which must be spent on the solution of TVI problems, the amateur is justified in taking time out to consider such activities objectively, especially with respect to the definition of the word "hobby." Indeed, TVI problems offer an interesting challenge to the ham who has an above-average technical background—but then the effort spent on study, experiments, and redesign can be greater than that which he expends on his vocation. With the basic purpose of a hobby in mind, i.e. relaxation, this TVI story by W2IYG departs from the style generally followed for technical articles.

THE de-TVIing of an amateur transmitter can be likened to a hunting trip. However, unlike the average sportsman, I cannot truthfully admit that I looked forward to the hunt. Frankly, the pursuit and capture of certain game ("game" being represented by spurious TVI-producing radiations) was motivated only by the generous bounty offered—carefree operation without TVI complaints.

For obvious reasons I refer to these interfering radiations as "beasties," and identify them by numbers (until they can be classified, according to species, and given scientific names). Those most numerous in the New York TV service area are beasties 2, 4, 5, 7, 9, 11, and 13.

It would be unfair to liken these obnoxious critters to any member of the animal kingdom. Actually, no man has ever seen a TVI beastie with the unaided eye; they can only be observed by means of a kinescope!

Although their natural habitat is the rf, if, and video stages of TV receivers, some beasties have been encountered in the audio stages.

History tells us that some of the early pioneers managed to capture beasties by means of traps (circuits, that is). Mechanical traps (shielded cabinets) have been found effective; however, Bring-'em-Back-Attenuated Seybold, W2RYI, has conducted many experiments to show that the elusive beastie can, among other things, escape from a metal cabinet—right through the cracks between panels!*

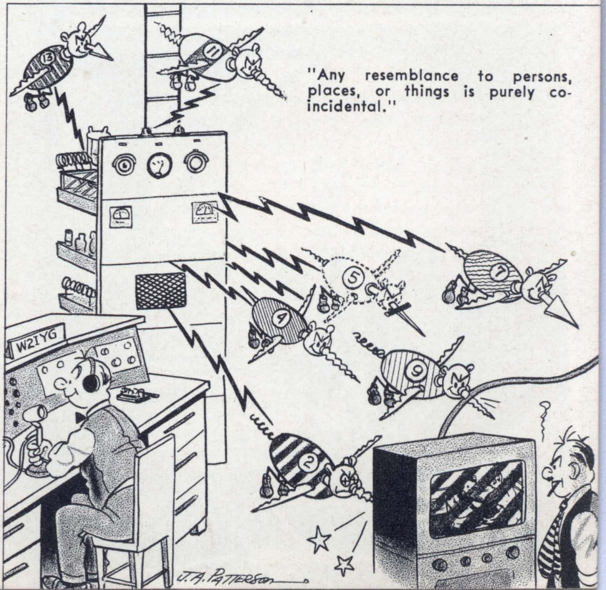
†*RCA Tube Dept., Harrison, N. J.*

Description of the Pre-TV Transmitter

The 600-watt, 14-Mc transmitter at W2IYG, mounted in a conventional, unshielded, open-type rack, did not employ any anti-TVI devices. The line-up included a converted BC-696 as a 3.5-Mc, VFO-exciter with a 1626 oscillator, and a 1625 keyed amplifier stage. This unit was connected by coaxial cable to the main transmitter which employed a 6L6 operating as a 7-Mc, 8-watt, grounded-grid doubler, and an 828 operating as a 14-Mc, 100-watt buffer-doubler driving an 833-A final amplifier.

Before this hunt began, I used various evasive tactics to avoid the beasties—live and let live. Many hams are no doubt using such tactics as "quiet-hour" operation, operation during the wee hours of the morning while the kinescopes are

*"*Shielding Experiments and TVI,*" *by A.M.Seybold, W2RYI CQ, June 1949.*



de-energized, etc. As the months rolled by, new TV antennas appeared nearer and nearer my humble abode. The beasties seemed to love the gadgets which people were having mounted on their roof tops, chimneys, window sills, and even within their homes. I realized that I must either hunt these beasties or else find myself being hunted by the neighbors!

TVI Checks

To bring the beasties within range so that I could study their characteristics, I employed a receptor device (a commercial TV receiver). Interference on my unfiltered TV receiver was very severe on channels 2 and 4, diminishing in severity through channels 5, 7, and 9. My TV set is located in a room directly under the shack. The TV antenna is situated in the attic about six feet below my 600-ohm transmission line for the 3-element, 14-Mc rotary beam, mounted on the roof of the house.

The pictures, and sound on channels 2 and 4 were completely gone. Channels 5, 7, and 9 fared a little better in that sound was available. The picture for channel 5 was almost washed out, the picture for channel 7 was somewhat better, and channel 9 displayed even further improvement; channels 11 and 13 were unaffected. The addition of a commercial high-pass filter had little effect in clearing up the interference. Telephone calls indicated that my transmitter was interfering with reception on TV receivers located up to ¼ mile from the transmitter. A test with a ham located at this distance confirmed these reports. He reported that interference was severe on channels 2, 4, and 5.

To become familiar with the beasties, I laboriously studied the extensive and detailed reports of others who had sought out the beasties and had captured them.* These successful hunters used many methods and various devices with great success.

The first step in this anti-TVI campaign was the sifting of this wealth of information on TVI elimination to determine the basic methods for preventing and eliminating TVI. Simple tests were made to determine the nature and sources of the spurious radiations from the transmitter; and finally, a study was made to determine the simplest method of obtaining TVI-free operation of the transmitter.

**See "TVI Bibliography" in the Winter 1950-'51, and Spring 1951 issues of HAM TIPS.*

Checking for Spurious Radiations

The existence of harmonics in the output of the average oscillator, frequency multiplier, or class C amplifier, can be easily verified because their frequencies are known, i.e., they are integral multiples of the fundamental frequency. Interfering signals from the transmitter, that fall within a TV channel, but whose frequencies are not harmonically related to the fundamental, are usually generated by parasitic oscillations.

Very-high-frequency parasitics can be as troublesome as very-high-frequency harmonics. Actually, the damaging results are the same in either case. Very-high-frequency parasitics can occur in any rf stage due to feedback within the tube (at some frequency other than the fundamental), when lead inductances and stray capacitances in the grid and plate circuits resonate at the same or nearly the same frequency. Many of the rules which apply to the reduction of harmonics apply here also.*

In spite of careful design and construction, very-high-frequency parasitic oscillations may occur. The following simple method was used to check each stage to determine whether parasitic oscillations were present: With the rf excitation removed from the stage being checked, and with all normal voltages applied, the grid bias for this stage was adjusted to the value where static plate current began to flow (without exceeding the plate-dissipation rating of the tube).

Plate current was then observed while the tank capacitor was varied through its range. The absence of sharp changes in plate current during this check indicated that parasitic oscillations were absent. A grid-dip oscillator is recommended for determining the frequency of the parasitic oscillation.** (When a grid-dip oscillator is used, be sure that all voltages are removed from the circuit.)

To determine whether fundamental oscillation was occurring in the stage being checked, a receiver was tuned through the frequency of the fundamental. The presence of a signal would indicate that this stage required further neutralization.

Inasmuch as the output of the transmitter did

**"The Pursuit and Elimination of Parasitics," by W.I.Orr, W6SAI, CQ, Dec. 1950.*

***The elimination of parasitics has been treated very thoroughly in various publications. The amateur handbooks are excellent references.*

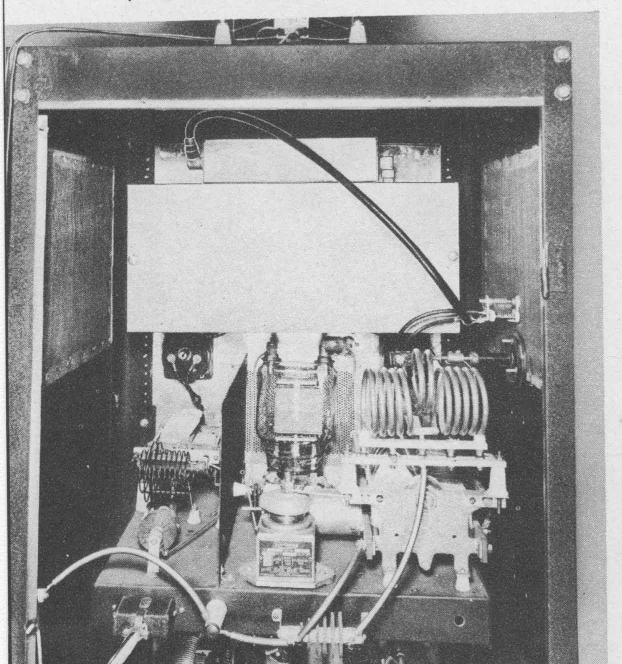


Fig. 1. Rear view of the shielded transmitter. Note the 56-Mc series trap on the plate cap of the 833-A, the louver shielding, and the paint-free edges of the cabinet for contact with the rear door (removed). The high-voltage capacitor on the left-hand side of the cabinet bypasses a B+ lead from an external modulator. The shielded box directly above the final amplifier contains the antenna coupler which is connected by means of a right-angle, coaxial fitting to the low-pass filter (mounted on top of the coupler).

not contain any parasitics, it was evident that harmonics were being generated in the transmitter. The strongest harmonic was causing severe interference on channel 2. The sources of the harmonics were located by noting the changes in interference on a nearby TV receiver as the final, buffer, and each of the exciter stages were disconnected, in turn. This check disclosed that the 833-A final was generating the strong channel-2 harmonic which interfered with reception on my neighbor's set, and that all stages were causing some interference.

How to de-TVI? (Modification vs Rebuilding)

After reading the literature on TVI, I was tempted to completely rebuild the transmitter; however, I gave serious thought to avoiding this drastic step because it meant tearing down an efficient transmitter. Nevertheless, the TVI problem had to be solved. With an open mind, I studied the constructional details of the transmitter and then carefully weighed the merits of rebuilding against those for modification.

Rebuilding. A new design for a TVI-free rf section would have to be based on the following factors:

1. Selection of a single-ended class C amplifier, instead of a push-pull stage, for lower second-harmonic output.[1]
2. The use of a final-amplifier tube of the tetrode or pentode type—an easy-to-drive tube eliminates the necessity for numerous exciter stages.
3. The utilization of a pi-type tank circuit for additional attenuation of harmonics.[2]
4. The use of low-capacitance, high-voltage capacitors connected between the plate and cathode (or filament) in rf stages (especially the high-power stage) to provide an effective and relatively simple means of reducing very-high-frequency harmonics generated in these stages.[3]
5. Minimum number of frequency multipliers.
6. Restriction of frequency multiplication to very-low-power stages if several frequency multipliers are required because of low-frequency VFO control.

Modification. To be made TVI-proof, it is necessary that the transmitter modifications:

1. Provide the necessary shielding to prevent direct radiation from the circuits.
2. Prevent the generation of harmonics.
3. Attenuate all very-high-frequency components (lying within the portion of the spectrum allocated to TV) in the output.
4. Prevent cables and leads, located outside the cabinet, from radiating interfering signals.

An appraisal of the transmitter in the light of these modern design requirements revealed that this pre-TV transmitter lacked all of these essentials for TVI-free operation. For example, the open-type rack did not provide the necessary shielding, and the meters required shielding to prevent them from radiating.

Because channel-2 interference was the strongest, much improvement could be effected by means of a 56-Mc trap in the tank circuit of the final amplifier. (Quite possibly, one of the other beasties may be causing you as much or more trouble. If this is the case, the parallel-tuned, series plate trap should be tuned to the beastie's frequency.) Harmonics which occur in each rf stage, and fall within the TV channels, should be suppressed as much as possible at their source.*

Planning the Hunt

Being an active DX man, I wanted to complete the TVI-elimination project in the shortest possible time. The object of this project was to solve the TVI problem without employing any cut-and-try methods. Because this requirement ruled out any time-consuming experimenting, a thorough job of TVI elimination could be assured only by the application of *all* of the basic methods for de-TVIing a transmitter.

Careful evaluation of the various TVI-elimination techniques revealed that I must use the following weapons: (1) shielding, (2) lead filtering, (3) output filtering by means of a low-pass filter, and (4) modification of rf circuits.

The Hunt

Girding my hunting gear, I set forth with confidence and determination. The details of the hunt are as follows:

A parallel-tuned, 56-Mc series plate trap in the final amplifier, and a six-section, M-derived, low-pass filter (together with an antenna coupler) were employed to obtain an attenuation of approximately 150 db. This attenuation was sufficient for beastie No. 2, the most troublesome of all, and more than adequate for the other beasties.

It cannot be emphasized too strongly that, to obtain this very desirable attenuation, it is extremely important that shielding and lead filtering be as near to perfection as possible. The following procedures describe the simple and straightforward steps which were followed to completely de-TVI the transmitter:

Shielding

The use of the open-type relay rack, having individual shielding of each rf unit, was seriously considered. However, this idea was discarded because many filter circuits would be required for the various leads connecting the individual rf units. Also, shielding of the individual rf units was avoided because each unit would require a specially shielded door to provide access to the plug-in coils.

Shielding provided by a conventional enclosed rack is insufficient for a TVI-proof transmitter because of the openings provided for ventilation, the cracks between panels, and those between the door and cabinet. Also, effective slots exist between overlapping metal surfaces wherever a layer of paint causes a separation of the parts of the cabinet.** Consequently, the entire transmitter (including power supplies), the low-pass filter, and the antenna coupler were mounted

[1] *"Down With Harmonics," by J.H.Owens, W2FTW, CQ, Feb. 1948.*

[2] *"Pi-Network Tank Circuits," by E.W.Pappenfus, WΦSYF, and K.L.Kilppel, WΦSQD, CQ, Sept. 1950.*

[3] *"More on TVI Elimination," by P. S. Rand, W1DBM, QST, Dec. 1948. "TVI Tips," QST, Oct. 1949.*

* *"Don't Pamper Your Harmonics," by P.S.Rand, W1DBM, QST, Feb. 1950.*

** *Each slot can radiate because it is equivalent to an antenna whose length is equal to the length of the slot.*

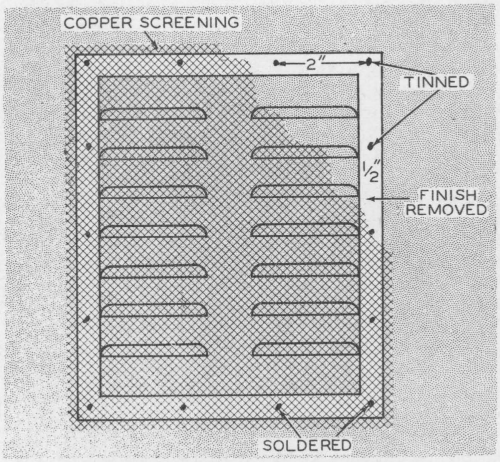


Fig. 2. Louver shielding details.

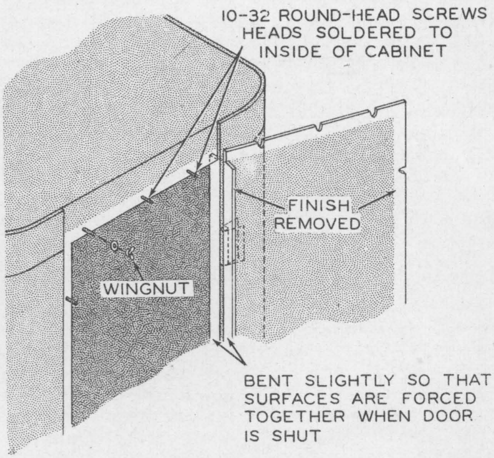


Fig. 3. Scheme employed to insure metal-to-metal contact between the door and rear edges of the enclosed rack.

within a modified enclosed rack.

In my particular case, I believe that shielding was the most important factor in reducing TVI because:

1. Thorough shielding provided by the modified enclosed cabinet prevents direct radiation from rf stages.
2. Shielding permits the external line filters and low-pass filters to function without interference from rf fields.
3. Complete shielding permits the use of unshielded and unfiltered leads within the cabinet.
4. Conventional circuits can be used in the exciter stages without resorting to critical constructional details and circuit arrangements.

Cabinet Alterations

The areas of overlap of the various parts of the cabinet were defined with the aid of a china-marker crayon. The cabinet was disassembled and paint remover applied with a small brush to those marked areas which were in contact when the cabinet was assembled. The softened crackle finish was then removed with a wire brush and the marked area was wiped dry with a clean cloth.

Shielding of the louvers was accomplished as follows: A frame-shaped area was marked around the louvers as shown in *Fig. 2,* and the paint was removed from the area. After the metal surface was thoroughly cleaned, a 500-watt soldering iron was employed to tin small areas located every two inches along the frame-shaped area.

Copper shielding, slightly larger than the outer dimensions of this frame-shaped area, was soldered to the previously tinned areas. For a smooth neat job, the screening was pulled up tightly before each point was soldered.

The cabinet was then reassembled with the paint-free areas making contact; the problem of providing metal-to-metal contact between the door and the cabinet was solved as follows: The paint was removed from the inside edges of the door and from the rear edges of the cabinet, along the entire area where the door overlapped the edges of the cabinet. (See *Fig. 3.*)

Since the door was not rigid enough to fit flush against the rear edges of the cabinet, a reasonably tight joint between the door and the cabinet was obtained by employing the scheme illustrated in *Fig. 3.*

The holes for the bolts are spaced about 10 inches apart along the rear edges of the cabinet. Roundhead 10-32 screws, a half-inch long, were inserted from the inside of the cabinet and the heads soldered in place on the inner surfaces. Holes were then drilled in the door to allow these screws to pass through when the door was closed. Wing-nuts were used to pull the door up tightly against the rear edges of the cabinet. Shielding at the hinge edge of the door was accomplished as shown in *Fig. 3.*

Cracks between panels were covered with strips of ordinary household aluminum foil (cut to a width of one inch) held in place with adhesive tape as shown in *Fig. 4.*

It has been shown that it is equally important for all meters to be thoroughly shielded to prevent them from radiating. The meters were shielded quite effectively and simply as follows:

1. Each meter hole was enlarged to a diameter slightly greater than the diameter of the beaded edge around the front of the meter case.
2. Paint was removed from the back surface of the panel around the meter hole.
3. A piece of ordinary copper window screening was cut slightly larger than the maximum diameter of the meter hole, and the meter was fastened to the rear of the panel behind the screening as shown in *Fig. 4.* This screening did not obstruct vision of the meter face since it was bowed out slightly by the beading on the case, as the mounting screws were tightened. Some of the meters were flat faced (without the beading); the screens for these meters were bowed outward by pressing the end of a rounded screwdriver handle against the screens before the meters were fastened in place.

Lead Filtering

None of the leads within the cabinet were shielded. However, an L-type filter was connected to each lead leaving the shielded cabinet.*

**This lead filtering prevents rf feed-back, which may occur when rf is picked up by the 110-volt house wiring, through the various filament and power transformers to the VFO and high-gain audio circuits.*

Most of these leads are 110-volt power leads and 6.3-volt relay leads which were relatively simple to filter.

Filtering of these leads was accomplished as follows:

1. The 110-volt power leads were connected to simple L-type filters in a shielded compartment mounted on the outside of the transmitter cabinet as shown in *Fig. 6*. The coils have approximately 50 turns on 1½-inch diameter forms.* All inductors and capacitors were arranged to facilitate short wiring, and each capacitor was connected as close as possible to the point where the filtered lead passed through the shielded filter compartment.

2. For each low-current, low-voltage lead which supplies relay power, bias, or B+ voltage, where less than one ampere of current is flowing, an Ohmite Z-50 choke was employed together with a 0.1-μf capacitor. Voltage ratings for these capacitors are given in the Lead Filtering Data, *Table I.*

*The inductance values of these coils are not critical. Wire size should be selected on the basis of the current-carrying requirement.

3. The L-type filter was used also for the high-voltage leads connected to the class B modulation transformer which was mounted in another relay rack. A 500-$\mu\mu$f, 10,000-volt television capacitor and an Ohmite Z-50 choke were employed in each of these filters.

Power for the VFO, located in the operating console, was obtained from a low-voltage power supply within the shielded transmitter cabinet. The outer shielding of the cables between these units were grounded directly to a point on the *inside* of the cabinet.*

*To prevent radiation of any very-high-frequency harmonics which may be picked up by the outer conductors of the portions of these cables located inside the cabinet.

Filtering of the Output

After shielding the transmitter and filtering

Table I — Lead Filtering Data

Lead	Inductor, L		Capacitor, C	
	Inductance	Current Rating	Capacitance	Volt. Rating
Low-Voltage, Low-Current (Relays, etc.)	Ohmite Z-50	To 1 amp.	0.1 μf	At least twice the voltage appearing between the lead and ground
Low-Voltage, High-Current (110-volt power leads)	See Text	See Text	0.1 μf	
Med.-Voltage, Low-Current (B+, bias, etc.)	Ohmite Z-50	To 1 amp.	0.0005 to 0.1 μf	
High-Voltage, Low-Current	Ohmite Z-50	To 1 amp.	0.0005 μf	

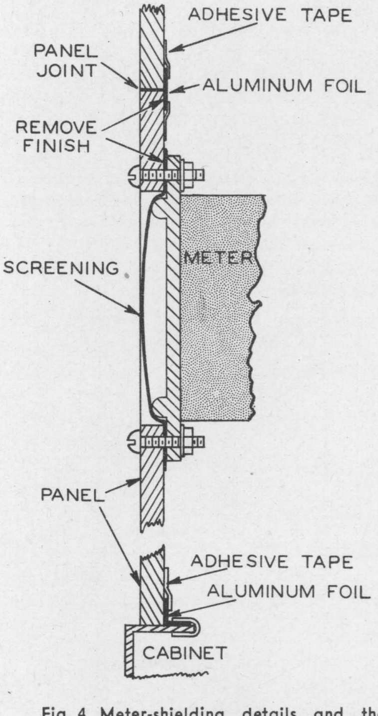


Fig. 4. Meter-shielding details and the simple method for sealing the cracks between panels.

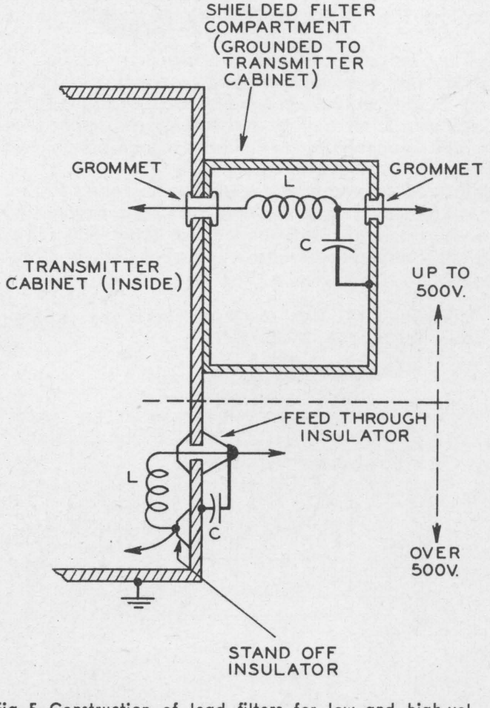


Fig. 5. Construction of lead filters for low- and high-voltage circuits.

I guess the trip to his TV receiver could be compared to the "last mile." You can imagine the suspense! As I walked down the street to his house, I began to recall the past few weeks of removing paint, scraping, filing, drilling, and soldering. Would all this be worth the effort? Would it be worth all the rare DX I had missed during the time I was off the air? I would soon have the answer.

I checked all channels on his TV set and found absolutely no interference on any channel. In a way, this was hard to believe, since a high-pass filter which I brought along was still in my pocket! Needless to say, my neighbor was just about as happy as I about the whole thing. My closest neighbor, about 50 feet away, reported he had no objectionable interference on his set.

Being interested in eliminating the channel-2 interference on my TV receiver, located in the room below the transmitter, I conducted further tests to determine which stage (or stages) of the transmitter was causing the trouble. The 600-watt 833-A stage was turned off without any noticeable interference reduction. Next the 14-Mc, 100-watt buffer-doubler was turned off, but the interference remained unchanged. Finally, the 7-Mc, 8-watt 6L6 frequency multiplier was turned off and no reduction in interference was noted. By the process of elimination, I knew that the 3.5-Mc, 8-watt VFO-exciter was the offender.

This unit is a converted BC-696 with a 1626 oscillator and single 1625 keyed-amplifier. With the key in the up position and the oscillator running, all traces of interference disappeared. The 3.5-Mc amplifier was causing the interference in spite of the fact that I had thoroughly shielded this unit. Feeling that there would probably be no interference from this VFO-exciter unit operating in the 3.5-Mc band with only 8 watts input, I had not observed the precaution of filtering the power leads as was done on the transmitter proper.

I traced the interference to the unfiltered power-supply leads for the VFO; these leads were radiating harmonics. This example illustrates the importance of lead-filtering when one wishes to reduce harmonic radiation to practically zero in close proximity of the transmitter, regardless of the power input or the frequency of operation.

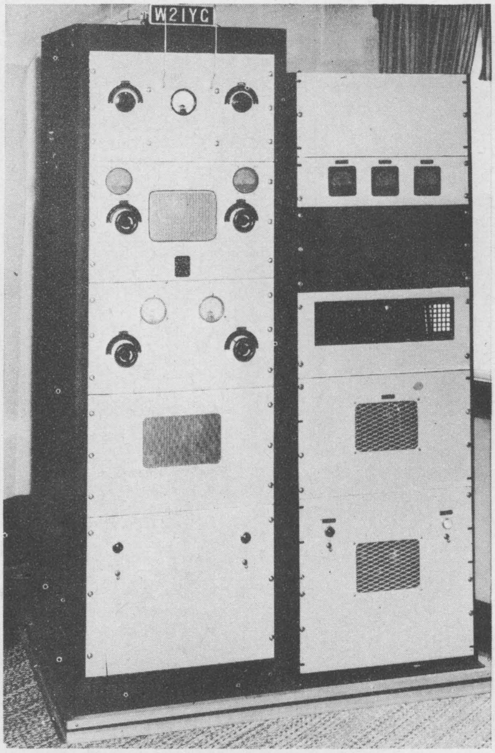
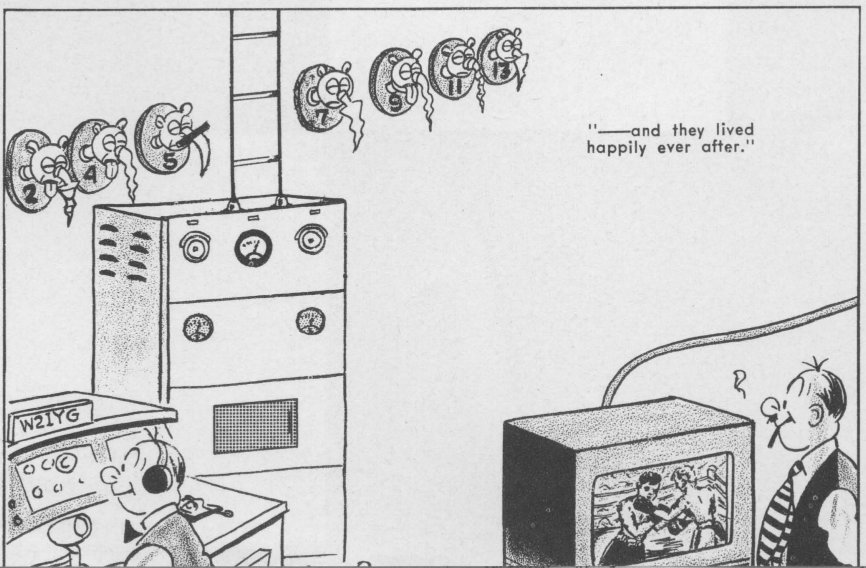
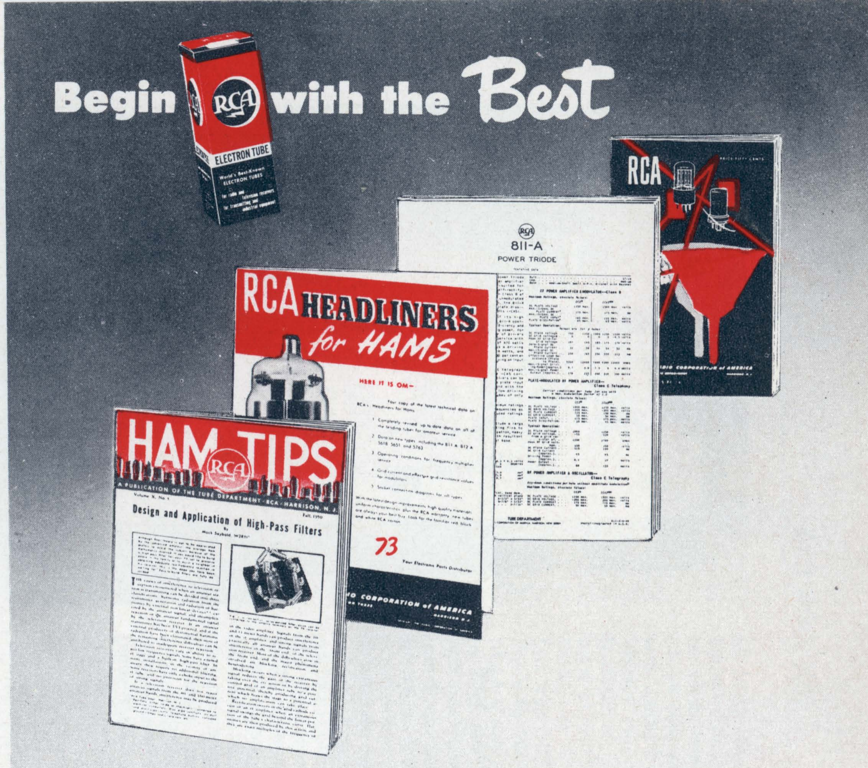


Fig. 8. Completely TVI-proofed and ready for operation. Before the transmitter was modified, the rf section (in the left-hand cabinet) was mounted in an open-type relay rack identical to the unshielded right-hand rack which contains the modulator. Observe the small-hole screen used in the panel-viewing windows in the rf rack. These windows were originally backed with the type of screening employed in the modulator rack. (The antenna meter did not require shielding because it was mounted in a shielded box enclosing the antenna coupler.)

The importance of shielding can be further emphasized by the following incident: One evening while I was working on the transmitter, with the rear door removed, my phone rang. It was a neighbor, five houses away, reporting interference on channel 2—and with the door on, he never knew when I was on the air!





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The "Twomobile" A 144-Mc Transceiver

By

H. W. Brown, Jr., W2OQN*

Both portable and mobile operation are becoming increasingly popular, and the current Civil Defense mobilization program has done much to stimulate and intensify this trend. The transceiver described in this article, nicknamed the "Twomobile" for obvious reasons, has displayed excellent performance in mobile operation and is readily adaptable to fixed-station or portable installations. In mobile operation, the Twomobile has made 100 per cent solid contacts with fixed stations located 35 miles away—the power output is approximately 1½ watts.

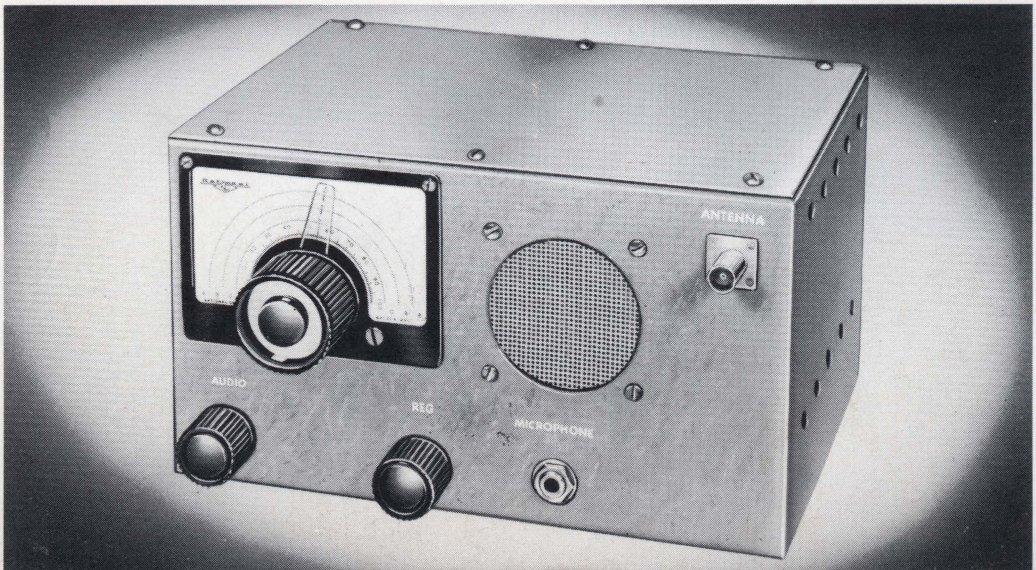
THE TWOMOBILE is a complete, compact, two-meter transceiver designed primarily for mobile application. Its carefully chosen tube lineup provides for efficient performance from a 250 to 300-volt, 100-ma vibrator-type power supply — power-supply drain, consistent with reasonable power output, was of prime consideration in the design of this unit.

The design of the Twomobile is quite straightforward and does not incorporate any complex or tricky circuits. The receiver section is a superheterodyne, using a superregenerative second detector. The transmitter section employs a 6AK6 tritet oscillator (with an 18-Mc crystal and 36-Mc output), a 6AK6 doubler, and a 5763 doubler-final.

During transmission, the receiver audio amplifier functions as the modulator. All switching from "transmit" to "receive" is accomplished by means of a three-pole control relay. Operation of this relay is controlled by means of a push-to-talk microphone switch. This relay, RL, switches the B+ voltage and the antenna from the receiver section to the transmitter section while simultane-

*RCA Aviation Engineering Dept., Camden, N. J.

Fig.1. The Twomobile—a straightforward, efficient transceiver for mobile operation.



ously opening the speaker voice-coil circuit and completing the ground connection to the cathode resistor of the final.

Receiver

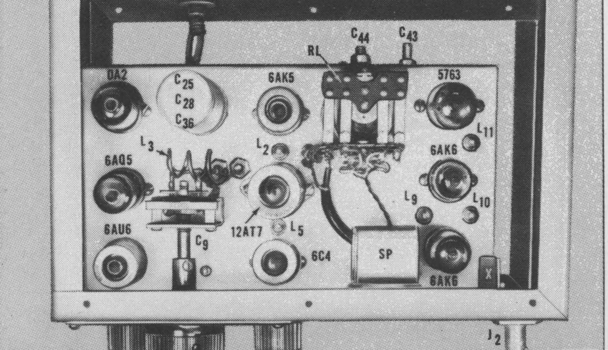
As shown in the receiver portion of the schematic diagram, it is apparent that the front end is of conventional design comprising a 6AK5 rf stage and a 12AT7 mixer-oscillator. The rf and mixer stages are both fixed tuned, thereby eliminating the usual bothersome tracking problem. At the frequencies that these stages operate, the operating Q of each coil is inherently low and little is to be gained by adding any extra tuning. Instead, these circuits are peaked to the approximate band center. A Hartley oscillator has been found to provide the best results in this frequency range. With the specified values of grid resistance and capacitance, the oscillator did not exhibit any tendency to superregenerate — a condition which so often plagues high-frequency oscillators. A one-inch length of 75-ohm twin lead, connected between the mixer and oscillator grids, serves as a coupling capacitor, providing optimum oscillator injection voltage.

The mixer plate is shunt fed through a 100-μh rf choke and is capacitance coupled to a 6C4 superregenerative detector. The choke is used instead of a resonant circuit, with some sacrifice in selectivity, due to the inherent difficulties, including "suck-outs," of coupling to this type of circuit.

The use of this detector has several advantages over a conventional intermediate-frequency system, especially for mobile work. It combines high sensitivity with desirable space- and component-saving features. At least three if stages would be required to provide the same gain. The selectivity is considerably less; however, in the interest of compactness, the loss of selectivity is a justifiable sacrifice. In this application the superregen's inherent avc and noise-limiting action is highly desirable. A squelch filter, consisting of C_{18}, C_{19}, and L_7, completes the detector circuit.

In a receiver of this type, the selection of the intermediate frequency is quite flexible, there being only one tuning adjustment, L_5, to consider. During the breadboard phase of the Twomobile design, frequencies between 10 and 75 Mc were tried satisfactorily. Although an intermediate frequency of 30 to 35 Mc appears to be optimum for satisfactory operation of the superregenerative detector, the use of a frequency in this range can present an interference problem (TVI in reverse) if the image frequency falls within a TV channel.

Fig. 2. Top view of the Twomobile. Note that this layout of components permits maximum utilization of the chassis area, and provides plenty of space between components for adequate cooling.



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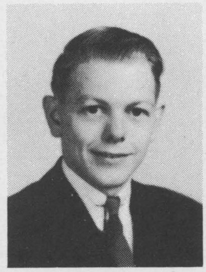


H. W. Brown, Jr., W2OQN

Wally has been a ham for more than fifteen years, operating first as W1KIQ from West Medford, Massachusetts. Upon graduating from Tufts College in 1942 with a BS in electrical engineering, he joined RCA Victor. In 1948, after spending six years as a design engineer in the Crystal Engineering Section, he transferred to the Aviation Engineering Department where he is now working on military communications equipment.

In the past few years he has written articles for *CQ* and HAM TIPS. A past president of the South Jersey Radio Association, Wally is currently on the board of directors, a member of its mobile emergency corps, and an enthusiastic participant in all its activities. His ham activities are primarily experimental, but schedules with his uncle, W1CWZ (who gave Wally his start in ham radio), keep his hand in on 40 and 80 cw.

His XYL is Madeleine, and they have two harmonics, Ronnie 10, and Peter 5. The Browns reside in Haddonfield, N. J.

In a high-signal area, such interference can be very annoying. To sidestep this problem, it was necessary to choose an intermediate frequency of 11 Mc even though the detector design became slightly more critical.

In actual practice, these images are usually low in signal level and, in many locations, cannot be heard. Outside the TV service areas, any convenient intermediate frequency may be employed. The image frequency may be calculated by subtracting twice the intermediate frequency from 144 (to 148) Mc. For those who prefer to experiment with various intermediate frequencies, one other more obvious precaution should be heeded: Select an intermediate frequency having harmonics which fall outside the two-meter band; i.e., do not employ the following frequencies: 24 Mc, 36 Mc, 48 Mc, etc. If a higher intermediate frequency is selected, detector coil L_5 should have a smaller number of turns, and the values of R_{10} and C_{16} should be changed to obtain the optimum quench frequency.

Audio Circuits

The first audio stage in the receiver section employs a resistance-coupled 6AU6. Since this audio system is also employed as a modulator, rf filters (R_{15}-C_{21} and L_8-C_{23} in the grid and cathode circuits, respectively, of the 6AU6) are incorporated to prevent rf pickup and resultant feedback during transmission. A 6AQ5 audio-output stage and a two-inch, permanent-magnet speaker provide a good working audio level.

During transmission, the receiver rf stages are disabled by means of relay RL which transfers

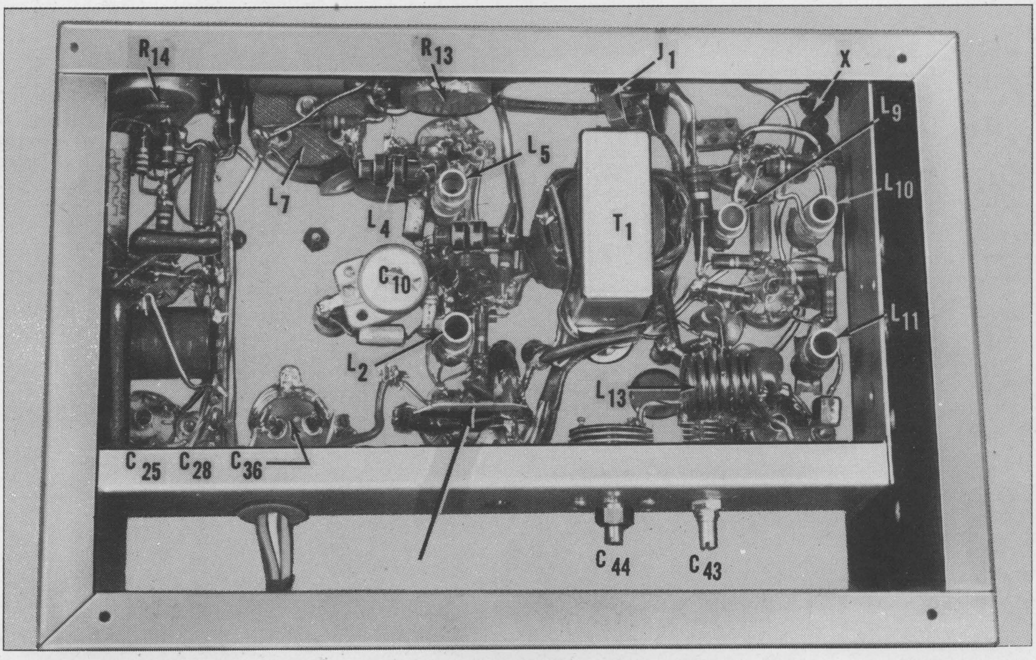


Fig. 3. Bottom view of the Twomobile. Note the accessibility of the components. Arrow points to a copper shield provided on the 6AK5 socket to prevent self oscillation of the rf amplifier.

the plate voltage to the oscillator and doubler tubes. A second set of relay contacts opens the voice-coil circuit of the speaker and grounds the cathode resistor of the 5763 doubler-final. Excitation for a carbon microphone is obtained from the cathode returns of the first two transmitter stages, and the microphone audio output is fed to the cathode of the 6AU6 audio amplifier. Only half of the primary of the push-pull output transformer is used during reception. During transmission, the plate current of the final flows through the other half of the winding. This arrangement tends to minimize the possibility of core saturation.

Transmitter

The oscillator employs the familiar tritet circuit using a 6AK6 and an 18-Mc crystal. In the Twomobile, frequency multiplication in any one stage is limited to doubling. An 18-Mc crystal was chosen because it is the highest-frequency crystal that is generally available at comparatively low cost.* Some suppliers do not keep 18-Mc crystals in open stock, but they can obtain them on special order, ground to any desired frequency. (The crystal used in this transmitter was received within two weeks from the time the order was placed.) A 12-Mc crystal, and tripling in the oscillator to 36 Mc, would possibly work satisfactorily, but driving power would be sacrificed. If this arrangement is desired, it is necessary to add a few turns to L_9.

The oscillator plate tank, L_{10}, is tuned to 36 Mc and is coupled to the 6AK6 doubler through capacitor C_{34}. In order to hold the capacitance appearing across the 72-Mc tank to a minimum, a balanced coil is used. This circuit is equivalent to a conventional split-stator tank circuit in that the 6AK6 plate capacitance and the 5763 grid capacitance are equivalent to the respective sections of a split-stator capacitor. This balanced tank-circuit arrangement provides appreciably more drive to the final than would be available from an unbalanced circuit.

A 5763 doubler does an excellent job as the output power amplifier. Here too, a balanced tank is used; however, in this circuit the inductance is fixed and tuning is controlled by capacitor C_{43}. The capacitance of C_{43} should be equal to the 5763 output capacitance. In practice, however, the coil is adjusted for a frequency as close to the center of the band as possible, with the capacitor set at approximately 7 $\mu\mu$f. Minor corrections and adjustments are then made with C_{43}. The choke L_{12} permits small unbalances with negligible effect on the output.

Mechanical Considerations

The entire rig is built on an 8 by 4½ by 1½-inch chassis; it is housed in a 5 by 6 by 9-inch box. The photos clearly show the chassis layout. In *Figs.* 2 and 3, the transmitter occupies the right-hand side of the chassis and the receiver is located on the left-hand side. The 6AK5 rf stage is at the rear of the center row of tubes, the 12AT7 oscillator-mixer is the center tube in this row, and the 6C4 detector is in front. The 6AU6 is located to the left of the 6C4 and, from front to rear, the 6AQ5, followed by the voltage regulator. The oscillator tuning capacitor and coil are mounted on a bracket which is mounted between the 6AQ5 and the 12AT7. The leads (thin straps) from this tuned circuit connect to polystyrene feed-through insulators. A ceramic trimmer is mounted directly on the grid feed-through insulator. As a precau-

**Some surplus 6-Mc crystals operate very satisfactorily as 18-Mc overtone units. This is especially true of the air-gap mounted type, the small plated variety usually having poor overtone capabilities.*

tion against self oscillation of the rf amplifier, a thin copper shield is soldered across the 6AK5 socket. This shield minimizes coupling between the input and output circuits. As in the construction of all vhf equipment, short, heavy ground and rf leads should be used.

The transmitter tube lineup starts with the 6AK6 crystal oscillator, located directly behind the front panel. This 6AK6 is followed by the 6AK6 doubler, and the 5763 doubler-final at the rear of the chassis. This layout places the antenna leads for both the transmitter and receiver close together at the rear of the chassis, thereby providing a convenient location for relay RL. The PA tank tuning capacitor and the series-link capacitor are mounted on the rear of the chassis as shown in *Fig. 3,* and are accessible through two holes in the back of the cabinet.

Ventilation and cooling of the unit is provided by rows of ¼-inch holes at the top and bottom of the sides and back of the cabinet. To dress up the appearance of the Twomobile, the cabinet was painted with gray automobile touch-up lacquer, by means of an inexpensive spray gun which operates from the air pressure of a spare tire.

Previous experience with mobile equipment emphasized the importance of making sure that all mounting screws are tight. The constant vibration encountered on the road will loosen mounting hardware in a surprisingly short time. For this reason, it is recommended that lockwashers, "stop nuts," or other means be employed to keep the mounting screws tightened.

Except where specified otherwise, all coils are wound on ¼-inch diameter, paper-base, slug-tuned forms. RCA Type 202L1 TV picture if coils (which are available at many supply houses) were used for this purpose after the original windings were removed. Other types may be substituted, but make certain that the cores are designed for high-frequency use.

Relay RL is shown in the schematic diagram as a three-pole, change-over relay; a four-pole relay is used in the Twomobile. Since relays are in critical supply at this time, it may be difficult to obtain a 6-volt dc, three-pole unit. If the required type is unobtainable, a single-pole and a double-pole combination, or two double-pole relays may be substituted for the three-pole relay. The other alternative is to rewind the coil of one of the many 28-volt relays that are plentiful in surplus. This modification is quite simple; e.g., for a conversion from 28 volts to 6 volts, the procedure consists of unwinding the coil and rewinding the form with wire which is six wire sizes larger.*

Alignment and Tuning†

Alignment of the Twomobile is comparatively simple. A grid-dip oscillator would be invaluable for this purpose but it is not absolutely necessary; the tuned circuits of the Twomobile can be easily adjusted with the aid of a wavemeter, an output indicator such as a crystal-diode, field-strength meter, signal source, and a 60-ma miniature lamp (pink bead) with a single-turn loop.

Receiver. Adjust the second detector to 11 Mc by varying the inductance of L_5 to where a wavemeter, tuned to this frequency and coupled loosely to L_5, pulls the circuit out of regeneration. (The frequency of the second detector may be checked more accurately with a communications receiver tuned to pick up the radiation from the detector.) The frequency of the oscillator should be checked with a wavemeter while trimmer capacitor C_{10} is adjusted. Set C_{10} so that the mid-range setting of the tuning capacitor corresponds to a frequency of 135 Mc. Connect a signal source to the antenna connector and peak the antenna trimmer, C_1, and the grid and plate coils, L_1 and L_2, for maximum output. (Adjust L_1 by squeezing or spreading the coil turns.)

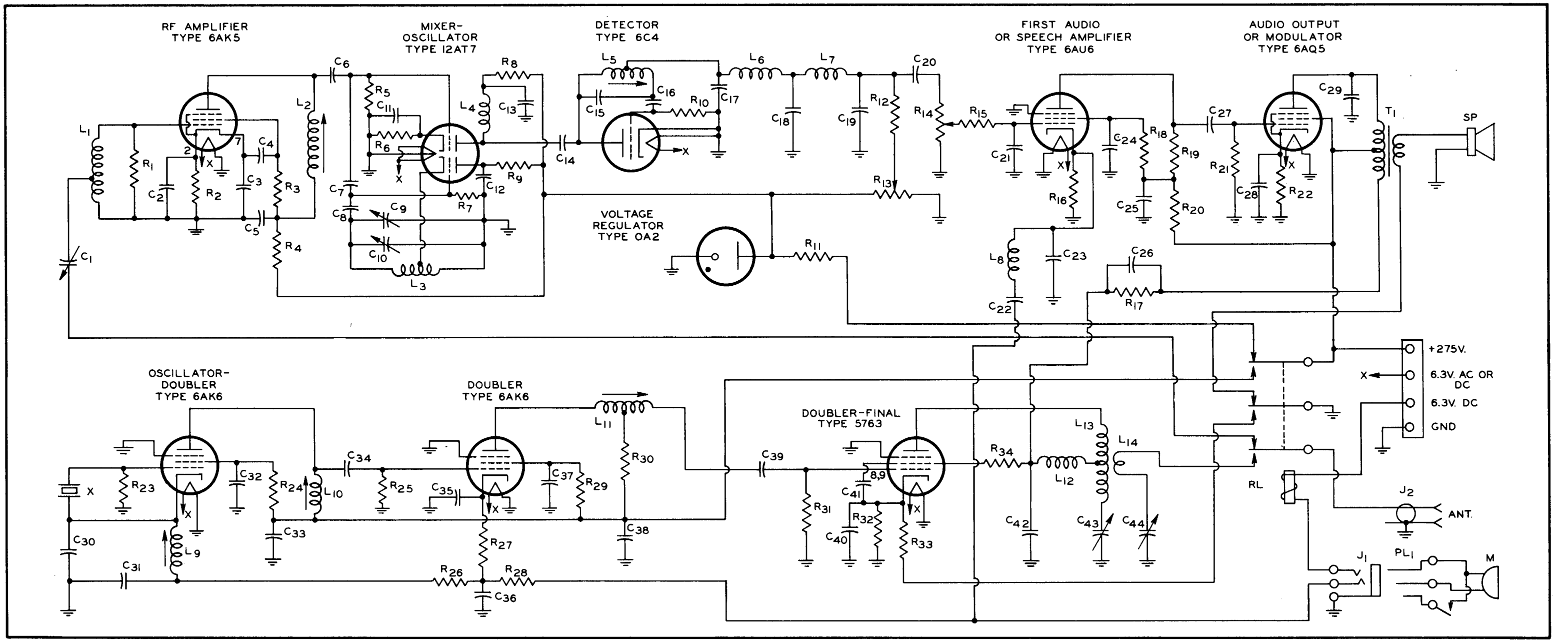
To obtain maximum performance from the receiver, it may be necessary to employ some cut-and-try experimenting with the tap position on L_1, the capacitance of the mixer injector capacitor, C_7, and the quench-frequency network R_{10}—C_{16}.

Transmitter. The first step in the tuning procedure is the adjustment of the oscillator inductor, L_9, to the point where the crystal oscillator starts oscillating. A receiver tuned to 18 Mc may be used as an indicator. Couple a single-turn loop with a 60-ma miniature lamp to L_{10}, the oscillator plate tank, and peak L_{10} for maximum output as indicated by the lamp brightness. Use a wavemeter to make sure that the plate circuit of the oscillator is tuned to 36 Mc rather than to a higher harmonic. Follow this procedure in tuning L_{11}, the doubler plate tank, to 72 Mc. Using the field-strength meter, tune the output tank to resonance by varying capacitor C_{43}, and adjust C_{44}, the output trimmer for maximum output. Alternately readjust C_{43} and C_{44} until the output is peaked as high as possible. Finally, go backward through the alignment procedure and peak each circuit for maximum output.

The transceiver is now ready for operation—happy Twomobiling!

"Converting D-C Relays," by R. B. Tomor, W1PIM, Radio News, *December, 1948.*

†*The antenna should be connected during alignment.*



C_1, C_{10} — 4-30 $\mu\mu f$, ceramic trimmer (Erie TS2A, N500).
C_2, C_3, C_4, C_5, C_{11}, C_{12}, C_{13}, C_{21}, C_{23}, C_{31}, C_{32}, C_{33}, C_{35}, C_{37}, C_{38}, C_{40}, C_{41} — 1,000 $\mu\mu f$, ceramic (CRL disc Hi-Kap).
C_6, C_8, C_{14} — 22$\mu\mu f$, ceramic (CRL tubular Hi-Kap).
C_7 — 1-in. length of 70-ohm twin lead.
C_9 — 2-plate, midget variable (Millen 20015, plates removed).
C_{15} — 39 $\mu\mu f$, mica (El-Menco CM-15).
C_{16}, C_{34}, C_{39} — 56 $\mu\mu f$, mica (El-Menco CM-15).
C_{17}, C_{18}, C_{19}, C_{27} — 5,000 $\mu\mu f$, ceramic (CRL disc Hi-Kap).
C_{20} — 0.01 μf, paper.
C_{22}, C_{26} — 10 μf, electrolytic, 50 wv.
C_{24} — 0.05 μf, paper.
C_{25}, C_{28}, C_{36} — Triple-unit electrolytic:
C_{25} 10 μf, 350 wv.
C_{28} 20 μf, 50 wv.
C_{36} 20 μf, 50 wv.

NOTE
All mica and paper capacitors should have a rating of at least 400 volts.

C_{29} — 3,000 $\mu\mu f$, ceramic (CRL tubular Hi-Kap).
C_{30} — 100 $\mu\mu f$, mica (El-Menco CM-15).
C_{42} — 2,000 $\mu\mu f$, mica (El-Menco CM-15).
C_{43} — 14 $\mu\mu f$, midget variable (Johnson 15M11).
C_{44} — 25 $\mu\mu f$, midget variable (type APC).
J_1 — 3-circuit microphone jack.
J_2 — Coaxial connector, UG-2900.

L_1 — 4 turns No. 16 enam., 3/8-in. diam., spaced to over-all length of 3/4 in., tapped 1 turn up from ground end.
L_2 — 3 turns No. 28 d.c.c., spaced to over-all length of 1/2 in.*
L_3 — 3 turns No. 12 enam., 1/2-in. diam., spaced to over-all length of 1 in., tapped 1 turn from ground end.
L_4, L_6 — Choke, 100 μh (National R-33).
L_5 — 22 turns No. 28 d.c.c., close wound, center tapped.*
L_7 — Choke, 80 mh (Meissner 19-686).
L_8, L_{12} — Choke, 144-Mc (Ohmite Z-144).
L_9 — 7 turns No. 28 d.c.c., close wound.*
L_{10} — 14 turns No. 28 d.c.c., close wound.*
L_{11} — 10 turns No. 28 d.c.c., close wound, center tapped.*
L_{13} — 6 turns No. 16 enam., 1/2-in. diam., spaced to over-all length of 1 1/4 in., center tapped.
L_{14} — 1 1/2-turn link, No. 16 enam., interwound in center of L_{13}.
M — Single-button, carbon microphone.
PL_1 — 3-circuit microphone plug.
RL — 3-pole, double-throw, 6-v dc relay (Potter & Brumfield KR-14D).

R_1, R_3, R_7 — 10,000 ohms.
R_2, R_{30} — 220 ohms.
R_4, R_6, R_8, R_9 — 1,000 ohms.
R_5, R_{18} — 1 megohm.
R_{10} — 820,000 ohms.
R_{11} — 5,000 ohms, 10 watts.
R_{12}, R_{20} — 27,000 ohms.
R_{13} — 50,000 ohms, potentiometer, 1 watt.
R_{14} — 250,000 ohms, potentiometer, audio taper.
R_{15}, R_{16} — 2,000 ohms.
R_{17} — 1,200 ohms, 1 watt.
R_{19} — 390,000 ohms.
R_{21}, R_{32} — 470,000 ohms.
R_{22} — 470 ohms.
R_{23}, R_{25}, R_{31} — 82,000 ohms.
R_{24}, R_{29} — 22,000 ohms.
R_{26}, R_{27} — 120 ohms.
R_{28} — 390 ohms.
R_{33} — 68 ohms.
R_{34} — 12,000 ohms, 1 watt.
SP — 2-in., p-m speaker.
T_1 — 4-watt output transformer, pp plates to voice coil (Merit A-2900).
X — 18-Mc crystal.

NOTE
All resistors 1/2 watt unless specified otherwise.

*Wound on 1/4-in. diam., slug-tuned form (from RCA 202L1 picture if coil).

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Plate current	150	150 ma
Plate input	90	65 watts
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